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SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

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Amorality in Industry

Science in the Southland

Fine Chemical Manufacturing

The Role of Geometry in Science

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SCHOOL SCIENCE AND MATHEMATICS

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A CAUSE FOR REJOICING

The early years of the existence of this journal tried out the metal of its promoters. That was a period of struggle, discouragement, experimentation, hard work and slow progress; but it was also one of foundation building and sturdy pioneering in a virgin region of rich educational and scientific resources. The originators had a vision of the value of the basic sciences in civilization, of the need for the extension of education in these branches, and of their dependence upon each other. At first mathematics and the other sciences were promoted independent of each other but it was soon discovered that, because of common objectives and reciprocal relations, united effort was necessary for progress. It became clear that meeting together for discussion of common problems, and the dissemination of discoveries and ideas by means of a journal for all teachers of mathematics and science were inter-related and dependent projects. This brought about the formation of the **Central Association of Science and Mathematics Teachers** and the union of *School Science* and *School Mathematics* into one journal, SCHOOL SCIENCE AND MATHEMATICS.

For a quarter of a century the association and the journal existed as separate but mutually supporting projects. Both grew and prospered, but one step more was needed to reach the goal. Finally in 1928 the dream of many of the leaders was realized when the journal became the nominal property of the association. Without funds the association officers called for volunteers and asked for a testimonial of faith in its future. From north, from south, from east and from west came the answer in checks. The only security asked or given was a prom-

A section of the banquet hall at the annual dinner of the Central Association of Science and Mathematics Teachers, St. Louis, Nov. 27, 1936.

ise to repay with interest within ten years. Then came the world-wide financial depression. Banks and business houses failed, schools closed or reduced and deferred salary payments and purchase of books and supplies, educational publications shrank in content and usefulness, and some suspended publication, or went completely out of existence. But the confidence of teachers and advertisers in the strength and durability of the structure they had built remained steadfast. The journal and the association marched on together. The attendance at the annual conventions increased, the association's work and influence was extended; the journal did not miss an issue nor decrease in size a single page.

Now *two years before the expiration of the ten year period* all obligations of principal and interest have been met. This association of teachers has accomplished what seemed impossible and today stands as the most inclusive and effective organization of its type in existence anywhere, owning and operating a journal for all teachers of mathematics and of the other basic sciences—a journal that is recognized and consulted the world around wherever science is studied and taught, the leader in its field.

The association recently held its thirty-sixth annual convention. This issue is devoted in large part to a report of this great St. Louis meeting and to some of the papers there presented. Teachers came from the source and from the mouth of "Old Man River" and from far back across the farms and grass lands to the foothills on either side. Next year the convention will be held in Cincinnati, the ancient center of the mound-builder civilization, the "Queen City" on the banks of the "Beautiful Ohio." The Central Association of Science and Mathematics Teachers, Inc., goes forward to enjoy the good will of an increasing membership, and of devoted journal subscribers everywhere.

GERMAN DRAIN PIPES SOURCE OF FAT

So acute is Germany's need for grease and fats that large scale recovery of drain pipe greases is to be undertaken, according to reports received at the Bureau of Foreign and Domestic Commerce from the American Consulate at Frankfort-on-Main. From 25,000 to 30,000 tons could be obtained annually from this source, it is estimated.

Salvaging drain pipe fats and grease is another side to the general problem of obtaining more fats for the German nationalism program which led, recently, to the plea by the Commissar for Food Control that Germans eat less fat in the future.

St. Louis, Nov. 27, 1936.

HOME GARDENING IN FAIRBANKS, ALASKA

By Edna M. Gueffroy
Illinois State Normal University, Normal, Illinois

Nearly two centuries have elapsed since white people came to Alaska and for sixty-nine years the country has been a possession of the United States, and yet the mass of the public is profoundly ignorant of this Territory from which considerably more than a billion dollars of wealth has been wrested through mine, forest, field and sea. The popular conception of Alaska is that of a frozen, treeless waste, infested with polar bears and inhabited by Eskimos who live in snow and ice houses. That such a description is more or less applicable to the Bering and Arctic coasts cannot be denied, but Alaska is too varied in temperature, rainfall, relief and resources to be pigeonholed with a blanket description. The broad interior plateau region, drained by the mighty Yukon, where long hours of sunshine and great heating make the shorter growing season of this region sufficient for grains and vegetables to ripen, is in strong contrast to the above description. Because of the abandon with which Fairbanks, Alaska flashes a variety of vegetables and garden color from June until September, it was selected as the spot from which to portray what interior Alaska can do in the way of gardening.

Location

Between the Pacific Range and the Rocky Mountain chain is located a high semi-arid plateau, varying greatly in width and gradually decreasing in altitude northward until the coast of Bering Sea is reached. Fairbanks (latitude 64° 51′ north, longitude 147° 52′ west) is situated in the very center of the northern end of this great plateau in the Tanana valley, a region which resembles very much the flat prairie of central Illinois. It is located at the northern terminus of the main artery of the region, the Alaska Railway, about 470 miles by rail from the coast at Seward, and 100 miles airline to the Arctic Circle. It is the largest log cabin city (2,000 population) in interior Alaska, the home of the Alaska Agricultural College and School of Mines (now called the University of Alaska), and the chief town and home market of interior Alaska.

Climate

Fairbanks, situated as it is between two great mountain sys-

tems, has a decidedly continental climate. The difference between the short, almost sunless, snow-filled days of December, and the verdant twenty-hour days of June and July, is almost the difference between two worlds. The lofty Alaska Range on the south presents somewhat of a barrier to the eastward movement of the continuous storms that sweep across the Gulf of Alaska, thereby concentrating precipitation along the coast and decreasing it in the interior, and at the same time preventing the oceanic winds from moderating the temperatures of the interior. The Endicott Range on the north effectively cuts off the interior from the steady winds that blow in from the ice floes of the Arctic Ocean. A low detached range extending north and south across the plateau country is usually effective in obstructing the tempering influence of the Bering Sea. (4, p. 270)

The outstanding features of the climate of Fairbanks are the great annual range in temperature, the comparatively light precipitation and the wide range in daily hours of sunlight. The range between the January and July mean temperature is 76°, as against 71° at Pembina, North Dakota, which is generally considered one of the coldest places in the United States. The absolute range at Fairbanks is 164°, and at Pembina 155°. (10, p. 494) The long days of summer are generally cloudy and cool, but brief periods of uncomfortably hot weather do occur in late June and July. In general any temperature over 70°F. is considered hot weather, and days with temperatures of 80° or over are sultry, producing a feeling of discomfort equal to a temperature of 100° in the mid-western states. It is surprising to many people to learn that the cumulative sun-work actually produces daytime temperatures of 90° in the shade in Fairbanks almost every summer. The highest temperature recorded by a properly exposed thermometer is 99° at this station. Curiously enough while the thermometer may register 90°, one can dig down in most places two or three feet and find hard, frozen soil—glacier as the natives call it.

Located within an area protected by mountains, Fairbanks receives little precipitation. Summer is the season of maximum precipitation, the four months from June to September receiving over half the year's supply. Though this precipitation is not high, being but little over an inch a month in the summer, and only about ten to twelve inches for the year, the low rate of evaporation and the perpetually frozen subsoil which keeps

the surface water from draining away makes this amount sufficient for gardening purposes. Most of the rain falls as steady light drizzles that may continue for several days. Winter precipitation in the form of very light and dry snow which totals 46.6 inches for a seventeen-year average is prized by the agricultural folk as it furnishes a protective covering to the ground and a spring moisture that augments the light summer rain.

Reckoned in days, central Alaska has a short growing season, Fairbanks reporting eighty frostless days annually, an average for twenty-nine years. While freezing may occur in any summer month, such temperatures are usually of short duration and do little damage. The most noteworthy fact regarding critical frost dates in Fairbanks is their extreme irregularity. Variations in the dates of spring or fall frost by fifteen days or more from the average are not uncommon. Thus no planting date can be stated for interior Alaska. Gardeners plant as soon as the soil is fairly well warmed up. Subzero weather occurs early in April and freezing temperatures are common in May, but the lengthening hours of sunlight quickly melt the winter snow and the surface layer of soil begins thawing. Ordinarily the first frost of fall, which comes late in August is followed by two or three weeks of delightful weather, and by middle September, freezing temperatures and snow flurries are common. The true value of a growing season lies not in the number of frost-free days however, but in the total hours of sunshine occurring during the season. Fairbanks, lying just outside the area of the Midnight Sun, has eighteen to twenty hours of light daily in mid-summer. Plant life, therefore, becomes mushroom-like in development.

Soil

Gardens located in areas of typical Fairbanks brown silt loam have the advantage of a soil that, in physical characteristics, conforms very closely with the friable brown loessial soil, Knox silt loam, which is one of the very good farming soils in our Middle Western States. Nearly all Alaska soils however, need fertilizer. Fairbanks gardeners and farmers find that air-dried peat from nearby bogs makes an excellent fertilizer, provided lime is added to neutralize acid reaction. Because of the scarcity of manures many gardeners of necessity resort to commercial fertilizer. Whether either peat or barnyard manure is used, the value of these fertilizers is not apparent the first year as bacterial action is slow in cool soils. The Fairbanks Agricul-

tural Experiment Station lists the following local materials as excellent fertilizers: dried ground fish, banana skins and stalks, dog manure, feathers, fresh fish scrap, kelp or seaweed, shrimp waste, fresh wood ashes, and leached wood ashes. (9, pp. 2–5)

Necessity of a Garden

Scurvy was for many years the most dreaded of diseases in the northland. Although the exact cause of the disease was not known at that time, it was known that fresh vegetables or raw fruit prevented or cured this disease. From early September until June no food of this kind could be brought into interior Alaska. Almost unbelievable prices could be obtained for fresh foods, particularly toward the end of the winter. For years fresh tomatoes were never less than one dollar a pound; turnips or rutabagas would bring fifty cents each if there were any for sale, and potatoes sometimes sold in excess of one dollar per pound. (8, p.1)

Today, thanks to improved transportation facilities and the stimulus and excellent service rendered by the Fairbanks Agricultural Experiment Station in disseminating agricultural information and in introducing and propagating for distribution improved plants, Fairbanks gardeners now grow almost as great a variety of vegetables as we raise here in the Middle West.

The Gardens

By careful planning and work, home gardens furnish vegetables in sufficient abundance to cheapen and to vary the diet of the inhabitants to a marked degree. The comparatively short growing season makes it necessary to crowd the vegetables along to enable them to mature properly before frost. In order to accomplish this result gardeners sometimes soak seed for several hours to hasten sprouting, plant indoors in seed flats or window boxes, or use protective and forcing devices such as coldframes and hot beds. Some of the slower germinating seeds are started very early in March, and others at intervals thereafter until the middle of April.

Cabbage is one of the best vegetables for the Fairbanks area. Gardeners are advised to plant early and medium late standard varieties as they are the most satisfactory headers. Late varieties are the best keepers but they can not be depended upon to mature. Cauliflower, which is handled in almost the same way as cabbage, except that the leaves are tied together after the

head appears, produces exceedingly fine heads. Early varieties of beets, carrots, and rutabagas are excellent root crops. The Petrowski variety of turnip which can be used for the table as well as for livestock was originally introduced from Finland through the United States Department of Agriculture. The yellow root four to eight inches in diameter is of excellent flavor and has the important characteristic of being highly resistant to attack by root maggot. Celery makes good growth if properly started and it can be stored until Thanksgiving or Christmas if set in the cellar in earth; parsnips produce well when planted in very rich soil and can be harvested in the fall or left in the ground until spring. Early varieties of Swiss chard, lettuce and radishes are planted out of doors as soon as danger of frost is

Cabbage is one of the best vegetables for the Fairbanks area

past and even before the ground has warmed up much. Peas, one of the most successful crops in the Fairbanks gardens, grow with a rankness rarely found in the United States. The best strain of peas for canning is a very early variety with a vine twenty to thirty inches long which requires approximately fifty-five days to reach the canning stage. The telephone varieties will reach eight to ten feet in good soil during a good year. Alaska peas ripen seed in the interior unless weather conditions are very adverse. Potatoes are the chief dependence of the northern gardener and are the most important cash crop grown in the Territory. Irish Cobbler is the most widely grown variety of the early potatoes. It has a sufficiently tough skin to withstand handling without breaking, but has an undesirable tend-

ency to produce deep eyes. White Bliss is another variety well adapted to Alaskan crop conditions. On good soils the yields vary from 200 to 250 or more bushels per acre. All vegetables average materially greater in size than in the outside world, but if they are larger they are unfortunately very watery. The nickname for locally grown potatoes is "waterballs."

Fairbanks gardeners are not without pests. One of the most common pests is root maggot, which is the larva of a small fly about the size of the common house fly, and of which there are several varieties. Crops which are most damaged by these pests are turnips, cauliflower, cabbage, rutabagas, and occasionally

A typical garden scene—Fairbanks

onions and beets. There seems to be little chance of eradicating this pest when once it has appeared, but some preventive measure such as clean culture, destruction of plants in the fall by burying or burning, and the use of corrosive sublimate helps control it. Cutworms sometimes destroy considerable garden stuff, although they are not nearly so widespread as are root maggots.

Greenhouse Gardens[8]

For the more ambitious gardeners a small greenhouse adds materially to the menu by furnishing lettuce, radishes and onions before outside gardens are in production. It also makes it possible to bring to edible maturity tender vegetables such

as tomatoes, peppers and cucumbers in a region where weather conditions would otherwise make such results impossible. Let us not forget that the Fairbanks greenhouse is looked upon more for vegetable production than for the production of flowers.

One may see several small greenhouses suitable for one or two families scattered about Fairbanks, the largest being about 14 by 16 feet and small ones about half this size, located so that they get as much sunshine as possible and as much shelter as possible from the prevailing winds on the north and northwest sides. Different types of construction are used, but all are characterized by the same principle, that is, the structures are of light

Fairbanks gardeners raise a great variety of vegetables

but strong construction the aim of the designer being the admission of a maximum amount of light early in the spring and late fall when the sun is not very high in the sky.

Some small greenhouses are built on the south side of the residence, the house forming the north wall of the greenhouse. Windows or doors permit heat from the house to enter the greenhouse when necessary. A Yukon stove, or stove made from a small steel oil drum or small boiler is in general use in the small greenhouses. This type of heating plant uses good-size wood which holds fire for hours. No use is made of the greenhouse for out-of-season growing of vegetables; it is much cheaper to store vegetables and buy those that cannot be stored than to operate a greenhouse during the winter. The cold weather, often

40° or 50° below zero, requires an expensive, well insulated house and a large fuel bill. Then too there is so little sunshine from November 1 to March 1 that plants do not grow well.

Some home gardeners save much time in bringing a greenhouse vegetable crop to maturity by starting the plants in a small box in the window and bringing them as far along as possible before they are placed in the greenhouse sometime in April or early May.

The tomato is the most important greenhouse crop raised in interior Alaska. Medium early varieties come to maturity in from 100 to 120 days, thus there is the need of starting plants in flats in early spring and transplanting to pots or cans when the first true leaves are well formed. When they are eight or nine inches high they are transplanted to the permanent beds. Best results are obtained by pinching off lateral shoots soon after their appearance and by training the plants to erect growth by tying them to wires or stakes. Since most varieties of tomatoes fail to set many fruits in Alaska unless they are artificially pollinated, gardeners are advised to tap the plants lightly every few days after the blossoms appear to insure success.

Lettuce ranks second to tomatoes in Fairbanks greenhouses. Black-seeded Simpson or Grand Rapids leaf varieties are started in the home before the greenhouse is warm and transplanted into beds after two or three weeks, or planted as soon as the greenhouse is warm. New plantings at short intervals throughout the summer insure fresh lettuce all season.

Cucumbers probably rank third in importance among Fairbanks greenhouse gardeners. Seedlings started in pots or cans are ready to be transplanted in the permanent beds at the end of a month. The young vines are commonly suspended by twine from wires five or six feet above the beds or supported by stakes to that height and then trained to spread over a trellis made of parallel wires stretched from stakes at the ends of the bed. Since cucumbers bear both staminate and pistillate flowers separately, it is necessary to pollinate artificially by hand.

Radishes, sometimes planted between the rows of tomatoes and cucumbers, are ready for picking in from three to four weeks after seeding. Onions supply another quick-growing vegetable in the greenhouses, requiring only about three weeks to develop new tops. Practically all onions raised in greenhouses are from sets of the Egyptian or Ebenezer varieties.

Greenhouse gardeners are not without pests. The aphid or plant louse is the most troublesome pest. It is more common than either the White Fly or the Red Spider, both of which attack tomatoes. Nicotine sulphate is recommended as the best spray to control this insect.

Flower Gardens

No account of gardening in Fairbanks would be complete without mention of the colorful flower gardens. Almost before the last traces of snow have disappeared under the increasing vigor of the sunlight, wild flowers of exquisite beauty seem to spring up everywhere. The purplish blue crocus, wild iris, and the delicate white blossoms of the Arctic anemone are sprayed

Pansy bed in front of the George Thomas Memorial Library—Fairbanks, Alaska

along the warm banks as early as the middle of May. They are shortly followed by golden buttercups and dandelions. The wild pink rose, lupines, and the yellow Alaska daisy are but a few of the many wild flowers of interior Alaska that could find their counterpart in many temperate sections of the United States.

Some gardens run to golden calendulas; others emphasize the bright red of poppies, snapdragons, sweet-scented stocks, the forget-me-not, Alaska's territorial flower, or perhaps pink and purple petunias, monstrous-sized pansies and dahlias. Sweet peas and nasturtiums climb the log cabins for five or six feet without special culture. It seems as if each variety is trying to

outdo the other in size and beauty, knowing its time is all too short.

Thus we have seen that during the summer months there is little to suggest the Arctic in interior Alaska. Writers have advanced optimistic and pessimistic views on the possibilities of successful agriculture in Alaska. While vast areas have no agricultural possibilities, yet considerable parts of the Yukon basin

During the summer months there is little to suggest the Arctic in Interior Alaska

are suitable for farming and gardening to a degree astonishing to the uninformed. The most extensive development in continental Alaska has taken place in the Fairbanks section where the home garden furnishes the grower and his family all the fresh vegetables that can be consumed during the growing season and sometimes a supply which can be sold, canned or stored

for winter use. Present garden results are merely indicative of what may be produced in other well-chosen parts of the interior in the future. We must recognize that agriculture as a whole is valuable in Alaska solely for the purpose of supplying the local market, and that in part only.

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RADIO BALLOON CHECKS AVIATION WEATHER

Rising over 30,000 feet higher into the air than the regular weather observing airplane here, a robot weather balloon has ascended high above the earth in the first night time radio meteorograph balloon ascension in this country. This pioneering flight was conducted at five a.m. (Nov. 30) immediately following the regular weather flight by airplane.

Dr. Charles F. Brooks, director of the Blue Hill Observatory of Harvard, found the minimum temperature of 77 degrees below zero Fahrenheit when the balloon reached a peak altitude of 50,000 feet, one hour and 12 minutes after its release from the earth.

While the radio speaking weather balloon shot up through the lower part of the atmosphere it showed the same form of temperature curve as that brought back by the weather observing airplane. There was a 13-degree fall to 3,500 feet, then a sharp 2-degree rise, followed by a 23-degree fall to 17,000 feet.

The instrument was designed by Dr. K. O. Lange and A. E. Bent, research associates at Harvard and built by R. D. Feiber. Dr. Lange and Mr. Feiber released the three balloons and instrument, and C. B. Pear, Jr., received the radio signals, which were recorded by two chronographs designed for the purpose.

The results, including a humidity record, will be reported to the International Commission for the Investigation of the Free Atmosphere, which designated November as a month for special effort.

STORIES OF FINE CHEMICAL MANUFACTURING*

By Paul A. Krueger
Mallinckrodt Chemical Works, St. Louis, Missouri

There is a unique difference between the manufacture of chemicals and all other forms of industry which imposes certain limitations on what an industrial chemist may safely say about the processes by which his products are made. The difference is this: The manufacturer of cans is able to predict almost to the unit how many cans he will get from a given piece of sheet metal, or the weaver of cloth can predict to the inch how much of a certain kind of cloth can be woven from a given number of spools of thread. In addition, these know that their competitors will be bound by the same yield figures. In other words, in these and similar cases, the yield of finished product from the raw material is almost implicit in the definition of the product. The manufacturer of chemicals, however, can seldom make such comforting calculations. Based on past performance records he may be able to predict accurately how much product his process will produce from a given amount of raw material, but rarely can he assume that his competitor gets the same yield. Since the improvement of established processes forms an important part of the industrial chemist's work, many of the most interesting stories of chemical manufacturing have to do with this phase of it. Since a manufacturer's knowledge of the factors influencing the yield of a process constitute a part of his assets, it is usually conserved in secrecy and the real inside story of chemical processes is rarely told. There is, however, a frequently little appreciated lighter side to the making of chemicals and I have assembled for your consideration some of the most amusing examples that have come to my attention.

This is usually thought of as the age of synthetic chemistry, as indeed it is, but the fact is often overlooked that the isolation of chemicals from natural sources forms, in reality, the back bone of the industry. It is only necessary to recall that sugar and alcohol are of vegetable origin, that plant and animal sources contribute the fats and oils so essential to the paint, soap, and food industries, that petroleum forms the raw material for some of the largest chemical industries, and that plants and animals

* Presented before the Chemistry Section of the Central Association of Science and Mathematics Teachers, St. Louis, Mo., November 27, 1936.

produce some of the most useful medicinals, morphine, quinine, the hormones and the vitamins, for example, to realize that much of chemical industry has to do, not with the formation of chemicals, but merely with their isolation in a pure state.

Among the sources of organic chemicals provided by Nature is the nut gall, a product of vegetable origin recognized more than 2,300 years ago as containing an astringent substance. The nut gall is today a primary source for tannic acid, which is important not only in its own right but also because it is sire to gallic acid and grandsire to pyrogallic acid, which is better known to photographers as "Pyro." The story behind pyrogallic acid is a combination of botany, entomology, geography, chemistry, and—in this version of it—some imagination.

Far up into the interior of China, two weeks by fastest runners from the nearest rail-head, there grows a kind of oak tree, each one a chemical manufacturer. Throughout the centuries, perhaps since time began, these oaks have suffered with a commendable and exemplary fortitude the affliction of aphids, or leaf lice. History does not record, nor does legend suggest, what sins the oak must have committed in its genealogical youth, but certainly to have been doomed to be afflicted forever with such a plague is strong indication of a misspent boyhood. Not only must the oak suffer silently this infestation of lice (although this may carry no social stigma in the Chinese hinterlands) but these are lice of a particularly lousy disposition. There comes a time in the life of every louse when, impelled by irresistible forces from within, it feels that life just will not be worth living unless it can bite an oak tree. Self-restraint being conspicuous by its absence from the louse personality, it yields to the urge, forthwith bites the oak in some tender spot, lays eggs in the incision, then no doubt goes on its way chuckling, with a fiendish glee at the discomfiture of its erstwhile host, abandoning principles and progeny.

With poetic justice, and probably in a moment of compassion, however, the harsh Nature which inflicted such a galling punishment endowed the oak with the ability to exercise vengeance, if not on its tormenter, at least on the rising generation of lice. From the incision in which the aphid lays its eggs the oak sends an excresence which gradually forms a hard, hollow shell, or gall, completely surrounding the eggs. These galls are of various sizes and shapes, but each is a prison in which the eggs of the irresponsible louse are incarcerated, and here it is

that each new generation of louse larvae first fail to see the light of day. If the larvae succeed in eating their way out of the gall, they may develop into mature aphids and louse life goes on. If they fail to break jail it is a victory for the oak. So far the contest is a draw. For all our natural sympathy for the poor old oak it is better so, because these galls form one of the most convenient sources of that important chemical, tannic acid.

Coolies pick, pack, and paddle the galls down river on rafts to rail-head and from there they follow the usual channels of commerce until they reach our warehouses. The wages of a gall picker must be infinitesimal, judging from the fact that galls are currently quoted at about twenty cents per pound on the San Francisco market.

Oak galls contain about 75% of water soluble matter. The first step in the tannic acid process is to crush the galls, place them in large vats, and leach out the soluble material with water. This extract may be evaporated to dryness to produce the technical grade of tannic acid, or may be subjected to solvent extraction to remove the tannic acid in a greater state of purity. The latter method leads to the medicinal, or U. S. P., grade. A special fluffy grade is prepared by quick drying of thin films of a tannic acid solution. An ordinary barrel of this grade contains only twenty-five pounds, so great is its bulk.

The historic use of tannic acid is for the tanning of leather. The ancient tanner, however, did not use tannic acid as such, but extracted it in his tanning pits directly from tanbark. It is an important mordant for the dyeing of textiles, is used as a clarifying agent in the manufacture of wines, and is of some value medicinally as an intestinal astringent. It has recently been found of great value in treatment of burns of the skin.

By the action of acids, alkalis, or bacteria, tannic acid is converted to gallic acid and a sugar. Gallic acid is used in the manufacture of inks and dyes, and to a limited extent, in medicine. It, in turn, decomposes into pyrogallic acid and carbon dioxide when heated.

So much, then, for the nut galls. A louse and an oak tree produce out of a mutual hatred an essential raw material from which we derive three useful articles of chemical commerce.

The manufacture of photographic chemicals is an exacting business, one which demands the utmost in chemical purity. There is a story of the early days of gelatine emulsion films and plates, told by Dr. C. E. K. Mees, director of research at the

Eastman Kodak Co., that illustrates the importance of the little things in this field. Some years ago, when the manufacture of photographic plates covered with a gelatine emulsion of silver salts was in its infancy, great difficulty was experienced in producing plates of uniform sensitivity to light. It was observed that different lots of gelatine gave finished plates of varying sensitivities, and in those days the only available cure was to test each new lot of gelatine and to blend several lots to attain any degree of uniformity of product. The Kodak Co. instituted research to determine the cause of this difference and finally succeeded in showing that the gelatine giving sensitive emulsions contained traces—about one part in 300,000—of allyl thiourea, a derivative of allyl isothiocyanate which is the essential principle of mustard oil.[1] Its presence in the gelatine was accounted for by the discovery that the cattle from whose hides, horns, etc., the gelatine had been obtained, had fed in fields in which wild mustard grew, and must have developed a liking for it. Cattle which grazed in mustard-free fields, or which turned up their noses at this bovine salad, gave a gelatine free of the mustard oil derivative and of low sensitivity to light when made up into a photographic emulsion. Since that time, needless to say, emulsions of uniform sensitivity have been produced. It is probably no exaggeration to say that modern photography owes much of its success to a cow with a dietary curiosity, not to mention its indebtedness to a feud between a louse and an oak tree.

The manufacture of fine chemicals is not always a science, but frequently is an art in which the experience of chemists and plant operators plays a large part. Nevertheless, it is safe to say that the old rule-of-thumb methods are rapidly being displaced by scientific methods of control which reduce or eliminate the personal factor of judgment. An example of such progress is found in the chromic acid process. You are all familiar with the action of concentrated sulfuric acid on sodium bichromate, the mixture used as cleaning solution, but it is not so well known that under the proper conditions the reaction products, chromic acid and sodium bisulfate, will separate into two immiscible liquid phases and that the chromic acid can be largely separated from the bisulfate by simple gravity separation. A good many years ago the plant operators developed a rather crude but effective test for completeness of separation of the chromic acid from the sodium bisulfate. The separated liquid layers were run

into pans to solidify and in order to determine whether the bisulfate was completely freed of chromic acid, the operator would direct an adequate quantity of tobacco juice onto the bisulfate. If the tobacco juice turned green, indicating an oxidation of the organic matter and a reduction of chromic to chromous ion, the bisulfate would have to be re-worked. If it was unchanged in color the separation was complete. Needless to say, this control test has been replaced by one which, though little more satisfactory, does less violence to one's sense of the aesthetic.

The little things are often of paramount importance in the manufacture of fine chemicals. A druggist once observed that when he incorporated potassium citrate in prune syrup, a heavy precipitate soon formed which rendered his medicinal product useless. Some samples did not give this reaction. Investigation showed that although the faulty salt passed all the then established tests for an analytical reagent and could be honestly labeled as of A. R. quality, it did show a trace of heavy metal which was finally found to be tin. The addition of a tin salt in the same proportion to the satisfactory samples caused the same precipitation with prune syrup. The difficulty was readily overcome by elimination of all tin equipment from the process.

Other examples of the importance of little things have been given by C. J. Darlington of the du Pont Co.[2] A certain acid reaction was carried out under pressure in a lead lined autoclave heated internally by a lead pipe steam coil. After several months of operation the coil failed and a new one was installed. This lasted only a few weeks, and from then on one coil after another failed in rapid succession after only short periods of use, without giving any indication of the cause of failure. Finally someone noticed the statement in an inorganic textbook that lead containing 0.04% bismuth was not very resistant to sulfuric acid. Analysis of the faulty pipe showed it to contain 0.03% bismuth. A pipe containing only 0.005% bismuth was then installed and failures stopped.

In another case,[2] a chlorination reaction was carried out in an enameled iron kettle and the time required for a chlorination was found by long experience to be 18 hours under the conditions of operation. During a six month shut down of the process the enameled kettle was used for another reaction. When the chlorination process was again resumed it was found that the chlorination, instead of requiring 18 hours, was complete in six hours. In the course of investigation of the causes

of this acceleration of reaction rate, it was observed that during its use on the other process the enamel of the kettle had been chipped and had been patched with cement. A few laboratory experiments showed that the cement catalyzed the chlorination and which component of the cement was responsible. After that, the catalyst was intentionally added and all chlorinations were completed in six hours.

Much has been written about the utilization of by-products in the chemical industries, but one of the queerest examples of this has to do with the disposal of spent cloves. A certain manufacturer of vanillin, which is the essential principle of vanilla beans, extracted large quantities of spice cloves for the iso-eugenol they contain, converting this by chemical means to vanillin. The extracted cloves were hauled away and dumped, used to fill ditches, and an attempt was even made to burn them, but no profitable method of disposal was worked out. Then an inquiry was received asking whether spent cloves could be dyed red, and if so, whether they could be sold at a reasonable price. A simple method of dyeing was found and a very considerable amount of red spent cloves were sold to a chemical exporting company at a price approaching that of the original cloves. With a wholly natural curiosity the manufacturer wondered what uses spent red cloves might have and learned that his by-product was being shipped to certain parts of Asia where cloves were in great demand as a preservative packing material for the preparation of human corpses for burial.

The chemical manufacturer does not always know to what uses his products are put, but because it is very much to his advantage to know such things there has been a growing tendency in recent years to spend more effort on sales and market analyses, and on technical service to the customer. One member of a technical sales department noticed that a Philadelphia shipbuilding company was buying, at irregular intervals, powdered sodium carbonate in three to five barrel lots. When the shipbuilder's purchasing agent was unable to say to what use this was being put, the technical salesman accepted it as a challenge and began a long period of correspondence, phone calls, and personal interviews with members of the shipbuilding concern in what seemed at times to be a hopeless hunt. No one seemed to know what sodium carbonate was used for. Finally, however, he was able to make contact with the man on whose requisition the carbonate had been ordered. It then came out

that this company not only built but also sold ships of all sizes, doing a considerable business in the smaller private yachts and cabin cruisers. They never knew at what moment they might be called upon for a trial run, a demonstration, or an inspection. A skeleton crew was maintained for such service, but for the personal service help—cooks, waiters, stewards, etc.—they were forced to take what help they could get or to transfer some of their own laborers to these jobs. A few unpleasant experiences proved that even after careful scrubbing their laborers often gave violent offense to nostrils of their prospective customers. The manager of this branch of the business had found, however, that if after their emergency help had been thoroughly bathed they were made to wallow in a bin of sodium carbonate powder, they remained sweet and pure, at least for the duration of the cruise.

In conclusion, let me say just a little in behalf of American chemical industry. It is a little appreciated fact that the United States produces more chemicals, measured either in tonnage or in value, than all the other great powers of the world added together. It is also true that in point of view of advances in manufacturing technology we have risen in the last twenty years from a position of relative obscurity to a position of unquestioned leadership. There are those who will subscribe to the belief that the most outstanding work in academic chemical circles is still being done abroad, but it is only necessary to review the recent contributions on fundamental questions by American chemists to recognize a very definite upward trend. Simple extrapolation of this trend justifies the prediction that in the near future American chemistry will be, in all respects, second to none.

References

1. See S. E. Sheppard, *Phot. J.*, 65, 380–7 (1925).
2. C. J. Darlington, *Ind. and Eng. Chem.* 27, 865 (1935).

The name of Gen. John Wheeler, Confederate general and commander of U. S. forces in the Spanish-American War, is now perpetuated in the newest unit of the giant Tennessee Valley Authority recently placed in operation. Wheeler Dam is at the upper end of the 15½-mile lake created by Wilson Dam at Muscle Shoals and has dual function of aiding upstream navigation and furnishing electric power from what will some day be a generating unit of 360,000 horsepower.

SCIENCE IN THE SOUTHLAND*

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This extensive title, "Science in the Southland," was more or less assigned to me, and I will not try to pretend being adequate to its breadth in this paper. As you can imagine, science work and science programs in the southern states are better or worse, changing with the locality. To collect information about science work, curriculum revision, new experiments and procedures, I depended mostly on personal contacts which I had already made with people who work in different state or city boards of education. I was able to obtain material from Louisiana, Texas, Arkansas, Georgia, and Alabama.

I sent out questionnaires to find out which courses of the different sciences are offered, and by how many students, boys or girls, they are elected and attended. Sorry to say that in New Orleans not one science course is required for high school graduation, not even general science, which is offered for one year. Until recently there was not even *one* biology class in any of the boys' public high schools, and this situation is changing very slowly. It is still considered to be adequate for girls to trifle with identifying flowers and dissecting grasshoppers, while it is a more boyish privilege to experiment with the lever and with the Wheatstone's bridge. I suppose this local situation is unique for the South.

As the other extreme, I want to mention Marietta Johnson's School of Organic Education, Fairhope, Alabama, where there are offered four years of science in the high school—general science in the freshman class, biology in the sophomore, chemistry in the junior, and physics in the senior class. The full four-year science course has been taken by more than ninety per cent of the students. The Metairie Park Country Day School, New Orleans, offers even more science courses because, besides the three specific sciences at senior high school level, it requires three years of general science in junior high school. But the school is too young and its program was gradually built up, so I can not furnish you with any statistical outcomes of this extremely rich science program.

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In most schools the science course to which the majority of the students is subjected during their high school careers, is general science, and among the specialized sciences it is probably chemistry or biology. The science course actually offered does not indicate the interest of the students, since so many smaller schools offer only one or two choices in specialized science in the senior high school, which reduces electives to one or two courses.

Going over the questionnaires which I sent out and had returned from different cities, I did not find them as revealing as I expected them to be, due to the fact that the statistical material from different boards did not allow a complete answer in requested specified terms. At least I got a heap of printed or mimeographed material, which the boards had put out during recent years, full of information and stimulating suggestions.

I want to use this material and a few of my own experiences as a basis to illustrate some science work which is done in the South. I hope you do not mind if I arrange this report in my own way—I mean if I take this address as a chance to discuss some general educational ideas with you. I will always return to my topic eventually, even though you may fear that I have lost it.

I have tried to group the challenging work in the teaching of science under three headings, consisting of some general objectives in science education; this offers me a chance to criticize some obvious new tendencies in the science teaching field.

The first of the objectives which I want to analyze, I would like to call, "The invasion of science into the grade school."

The second one I want to call, "The search for a vital objective in high school science."

The third one may be formulated as "The inertia of the high school science curriculum."

Do not expect that I will give an answer at the outset as to how these problems are dealt with in the South. Let me first analyze each one in order to find out its educational value and its psychological function in our educational program. What I intend to do is to arrive at a clear, theoretical understanding of science learning and of the rôle science as knowledge and method plays in the educational process. I believe that we choose the safest way in revising or reforming our science work if we have a basically sound and correct psychological understanding of this trinity: the pupil, the learning process, and the program. The theoretical conclusions at which we may arrive, I want to

compare with the actual work which is done; that means that after each psychological excursion I come back to practical implications and practical answers originated in the South.

Following such a scheme, I hope to avoid telling you things which you already know or which are only of statistical significance. By this I hope to succeed in showing you where changing and challenging teaching and thinking is going on in those parts of the South which I know.

As to the first point, "The invasion of science into the grade school," I am afraid that many of you may object to this issue as not belonging here but in a meeting of elementary teachers. I do not believe that is right. Do you really think, if you are teaching science in high school, that all former science experiences of your students would have no bearing on their present attitude towards science in general? I mean do you really think that your students' attitudes concerning serenity, maturity, open-mindedness, interest, and originality, which are exhibited in the greatest variety and degree—do you really think that these attitudes are just the result of chance? Probably not. They are conditioned just as well as other traits and skills. We, science teachers of the high school, could give this conditioning process a little more thought, and we should not narrow ourselves down to the subject-matter we teach. To understand the psychological condition of the pupil is just as important for the teacher as to know thoroughly the subject-matter of his field. I suppose this is a point which needs some more consideration, and, if possible, some more convincing disclosure.

Every teacher attempts to get the student's interest in that which he is teaching; he wants to have his whole-hearted concern because only then can he be sure of a worth-while success. Changes of programs have tried always to adjust method and material in order to bring in closer reach this desired goal. The slogan of the Progressive Education has always been, "Meeting the Need of the Child" because that assures us of his active participation. Behind this is the clear understanding that interest is an indispensable factor for successful learning. Everybody has made the observation with children and with himself that the greater the interest, the easier and faster the mastering process of any intellectual knowledge, and just as well of any physical skill. This holds true where there is no drawback of specific inhibitions of organic as well as neurotic nature.

To bring in another every-day observation, which finally may

help us towards an understanding of learning, is the fact that we are eager and interested to grasp further information about things which are somewhat familiar to us. It is like meeting old friends or touching familiar ground. The same process takes place when children in their early school years are exposed to science experiences, as many and varied as possible. When they have reached high school level, they already have many ties to the advanced studies of science, which color decidedly their interest in it. They get a great deal of satisfaction out of this recalling of early learnings, which leads, on the other hand, to a smoother and more active mastering process of new problems.

Where there is interest, there is optimal learning guaranteed, variable according to individual ability. It is self-evident that interest is one feature of students' traits with which we are constantly concerned. What is this attitude called interest? Consulting Webster's dictionary instead of a textbook on psychology, I found a very revealing definition, which reads: Interest is "excitement of feeling, accompanying special attention to some object." The emphasis of this definition rests on two things: on the emotional charge and on the selective limitation. I could not have found elsewhere a more complete and compact definition. It tells us that, entering the field of interest, we move on the dynamic ground of emotions. In spite of Terman's extensive studies, nobody would doubt this any more, because every-day experience offers enough proofs. In common with all emotions, interest has the aim of avoiding discomfort and seeking satisfaction. We will keep this in mind in constructing a layout of curricular changes. The aim of interest to avoid discomfort is obvious when we are getting hungry and suddenly turn our interest towards food. This interest of a starving man can be so intense that it leads to actual hallucinations, which are often reported from expeditions into ice or desert.

The purpose of interest in seeking satisfaction is perhaps not so obvious. But if you ask a number of children to write a list of the things that they have seen in the window of a shop which they often pass, we find that the list of the boys and girls contains exactly the objects of their specific interest. The rest of things were merely overlooked because they did not stimulate any wishful imagination. Making this observation, we become aware of another characteristic which distinguishes interest—namely, its selectiveness. The selectiveness is determined by the individual search for satisfaction. That merely means that the

same object has different value for different people. An amusing illustration is a story told of the composer, Batiste. He was in his early life employed as a scullion, and it is said that he discovered that each of the vessels that it was his duty to scour possessed a musical tone of its own. Soon he had arranged them in a scale and was able to play compositions of his own upon them. The chef, who regarded cooking pots from another point of interest, was naturally annoyed, because cooking was *his* one interest in the kitchen. Another such illustration came out of my biology class. One day I asked a girl to look into the microscope, where I had set a slide showing a cross-section of an earthworm; it was stained scarlet with hematoxylin and, with deep admiration for the microscopic sight, she uttered: "What a beautiful color for a dress!"

We have to consider this selectiveness of interest. I remember another instance when we had been studying some botany on a general science level, and I did not get the interest and cooperation of one girl, who was highly artistic and interested in fashion. I suggested to her that she design a pattern for material made up of leaves or flowers taken from the local flora. This she did with success. At least it made her appreciate nature and opened her eyes for its beauty, richness, and variety. And is that not *one* of our goals of science instruction: to cultivate appreciation of science values, in whatever form they may find expression?

Referring to our conclusions concerning interest, namely its emotionality and its selectiveness, I want to propose that our aim in *high* school science teaching is to separate the close linkage of the two elements, which means becoming capable of postponing satisfaction and paying due interest for a longer stretch of time to the task in hand. This attitude we are used to call concentration. But in *lower* school science the main aim is to stimulate interest and to make further investigations alluring, attractive, and accessible. We cannot expect boys and girls entering high school to be interested in science if they do not already know its faculty for answering vital questions. We can not expect students entering a biology class at fifteen to be suddenly interested in biology. The appreciation and expectation for it have to be built up. This is mainly the work of the elementary school.

Psychology has taught us in the last decades, with enough satisfactory proofs, that traits are formed very early. We are not astonished to hear of reading or writing problems at high school

level which originated in the primary grades. They are too often the symptoms of an early resignation resulting from serious discouragement, which colors the pupil's whole attitude towards similar experiences wherever and whenever they may turn up again.

Science as the enlightening power for the understanding of the world around us, means for a child at least as much as arithmetic, and needs to be fostered at an early age. Every general subject of high school level already has its established roots in the elementary school, except science; and science is certainly much too important and vital in its function to be left to nature walks and flower gardens.

I consider it to be of greatest importance to assure the elementary teacher of the cooperation of the high school science specialist to build up his science work at elementary level. We will be surprised in high school at the science-mindedness with which the students meet us when they do not begin but continue investigating the world. Especially where there are both school types—elementary and high school—under one roof, it is extremely advantageous for the science teacher to cultivate the contact with smaller children. I, at least, enjoy very much diving from senior physics, chemistry, or biology to first-grade level. I am again and again surprised at the keenness of observation, interest, and intelligence with which the children of primary and elementary age ask, answer, and discuss. It keeps me aware of the growing process in children, and I understand my seniors, perhaps, better after having experienced their determining past through dealing with children of tender age. I believe this consideration essential, since I look at high school science instruction more in terms of developmental values than in terms of subject-matter achievement. I have more to say about this later.

After having discussed the importance of early science experience and its bearing on the later attitude towards science in general, I want to report what practical contributions the South has to make to the question. I noticed a decided concern of the respective boards with this matter. From Arkansas and Georgia I got material of planned science programs which begin as early as kindergarten. The Georgia Program for Improvement of Instruction has drafted a tentative plan of seven basic objectives (two of them are mainly concerned with science) which are gradually built up, broadened and deepened, and

cover the range from kindergarten to adult education. This at least indicates a cooperation of all executives of all school levels; it indicates the tendency to build up a consistent plan, including science through the ages. The Arkansas Cooperative Program to Improve Instruction gives elementary science special mention in its bulletin. It emphasizes the appreciative nature of such instruction and the development and understanding of basic science principles. In the model school of the Louisiana Polytechnic Institute I have seen splendid elementary science work going on and constructive integration between high school and elementary staff.

At the end I would like to say a few words about the elementary science work at the Metairie Park Country Day School, New Orleans, with which I am connected. As the theoretical basis to build up a program, we made use of the analysis of interest as well as the function of science for the child's mind. We felt that children in the grades need more science information than the average teacher is able to give them. In this case the elementary teacher calls upon the specialist. I answer questions only so far as the interest of the children leads. They are always thrilled if they can do things, but they like also to talk about everything they have seen and are bothered by not understanding: whether it is the puppy which has no recognizable father or the chicken which can not drink like a dog, whether it is the egg which has two yolks or the engine which has different sized wheels, whether it is what makes you mad, what stops your growing, or what makes you die. Even if we cannot answer all this, it is at least reassuring for the child to know that it is not alone with its struggle and its ignorance.

The microscope, for instance, can be used even in the first or second grade. Let the children get used to this instrument. Don't we, educated adults, use many things and not know how they work. Probably only one-tenth of one per cent of radio listeners understand the mechanism. I do not hesitate to dissect with the fifth or sixth graders the heart or the eye, and have just as much intelligent response, if not more, as I have in the tenth-grade biology course. The lower the age level, the less systematic or complete I try to be in the discussions. The advantage of informal and casual information must be realized. All anthropomorphism which penetrates most of children's nature books has definitely to be given up.

The interest of early age is entirely selective; information

which is forced upon the child's mind is not assimilated or is forgotten as quickly as possible. This has its reason in the symbolic value of mechanical or biological facts for a child's mind of early age. But time does not allow me to go deeper into this subject.

The meagerness of associative material in younger children is remarkable. This leads often to unusual associative pathways, as illustrated by the expression of the first-grader who says that soda water tastes like a leg which has "gone to sleep." This expression is entirely age-adequate; we should not try to criticize. *One* task of science instruction at this early level is to enrich the associative material so it can be used later for systematic learning.

Even though the importance of all the points so far mentioned are more and more realized by elementary and slowly by secondary educators, there is still no method or approach generally accepted. It will be the work of the coming years to build this up, and I hope that the high school science specialist feels some responsibility in dealing with the question because it is certainly to his advantage. Also teachers' training has to be revised according to the new needs. So far as I could find out, there is no teachers' training institution in the South which has yet adapted itself sufficiently to the situation.

I am afraid I have spent almost too much time on this subject; but I see so many educational and psychological implications of utmost interest in it that I wanted to call your attention to some of the main points of the problem.

Let us go to the second objective, which I want to analyze and which I called, "The search for a vital objective in high school science." I refer here to much criticism recently made by different responsible educators. All of them emphasize as one characteristic of the present educational situation the inconsistency, the insecurity, the confusion. Robert M. Hutchins, in an article published in *Harper's* for October, 1936, said: "The most striking fact about the higher learning in America is the confusion that besets it. This confusion begins in high school. . . . The high school can not make up its mind whether it is preparing students for life or for college." John Dewey and Charles H. Judd have stressed similar considerations in recent papers.

The question I want to discuss is: What is the meaning of this rather vague demand of educating for life? I can tell you

that the educational work in the South is not without practical answer to the problem; but let me follow again my scheme and start at the bottom of the problem, trying to build up an educational philosophy which enables us to approach the practical work critically.

"The validity of a course of study," as H. C. Morrison has already stated, "rests on the disclosures of the underlying sciences of psychology, biology, and anthropology." This means that the practical school work has to be determined by the mental, physical, and evolutionary knowledge of the individual to be taught. As I see it, there are behind each learning process, of whatever subject-matter it may be, two clearly distinguished outcomes. One of them is the pure knowledge we get and the other one is the influence that knowledge has on the personality in order to develop its adaptive abilities. Both of these outcomes have not necessarily to run parallel, and can only theoretically be separated. Our instruction can emphasize one or the other. We know that traditional education worked more or less towards the first goal, and we hear at the present time more and more mention of the exclusive importance of the second. Can we perhaps, with this distinction in mind, attack the question of what is meant by educating for life? I hope so, if you admit that the high school is no place for vocational training and that the latent powers of adaptability, cooperation, initiative and interest are of greater importance than the load of factual data which may be obtained.

I do not want to belittle the value of factual knowledge; I just want to recall the research done concerning the retention of science information after a period of time. As you know, it is low and contains little factual material. The retention of scientific methods or practical implications is much higher. Nevertheless, there is uttered the doubt whether the functional importance of studying science at high school level can be measured by the percentage of retention at all; whether there are no structural values in it, which may affect the mind and have their bearing on the development of the whole personality. As you can see, there is no clear-cut educational philosophy which could assist us to base upon it an adequate course of study. Nevertheless we can make this general statement, that educating for life is to consider method and program as means to bring about adaptive abilities in the personalities of students. I mean adjusting method and program to the psychological needs of a

given age in order to foster normal growth, mentally, emotionally, and physically.

If we turn again to our subject of science teaching and apply the above statement, we have to agree first on a few psychological pre-requisites in order to be able to criticize or reorganize method and program. First of all, we have to know more about the psychological foundations of the high school age-level. So far as the general science age-level is concerned, we have to arrive at an understanding of pre-adolescence, and so far as the specific science age-level is concerned, we have to be certain about some basic issues of adolescence.

Pre-adolescence is characterized through the physiological process of increasing inner secretion of the maturing glands. This causes a decided disturbance. The "ego," or self-controlling system, is neither prepared nor capable to counteract this invasion of emotional quantities. As obviously this leads to an unbalanced state of mind; inconsistency, roughness, opposition, short concentration span, day-dreaming, disciplinary troubles are to a great extent characteristic of this age. Physically we can notice a decided unrest, which has little chance to enter constructive channels during ordinary sedentary school hours. Under disciplinary pressure, the mind turns easily to the satisfactions of day-dreaming or secret mischief. We probably agree that discipline achieved by these escapes is not worth while, even though it produces a presentable external behavior.

Out of these and some other considerations, I think that general science offered at pre-adolescent level should be as active, practical, and investigatory as possible. An activity program, as it is worked out in the elementary school with so much success, is the right working method for science at this age. "Doing things" is the slogan of this unstable and oscillating mind; its enthusiasm, even if short-lived, is nevertheless sincere. As little lecturing as possible, I think, promotes study most successfully. This seems a contradiction in itself, but it just means that the information which is again and again needed by the student to carry out a started project leads to a considerable accumulation of factual knowledge. The systematic incorporation of it is the work of advanced senior science. The ideal place for general science is a combination between a laboratory and a shop, with enough outdoor space to keep animals and plants, to study weather, stars, sun, moon, and shadows. As a friend told me the other day, the method suggested here is

more or less the one which is practiced at the Fieldston School.

I never made direct use of a science text book in a general course. We turned to it as a reference book and source of suggestions but did not follow a pre-arranged collection of topics, which is admittedly rather arbitrary. The inclusion and placement of the topics is determined by an encyclopedic attempt for completeness rather than by the psychological characteristics of the learner. And—by the way—if science is an issue from the first grade on and the general science course in the junior high school extends over three years as, for instance, at the Metairie Park Country Day School, New Orleans, or at the public schools, Houston, Texas, there is little danger of omitting vital objectives.

It is interesting to mention that most important science problems are brought up by the students themselves. I remember one instance when a boy wanted to take apart a broken hair-dryer. He opened the casing and looked at the motor, finding that it looked different from the school model of an electric motor which had only two poles. He followed up the problem, and using the teacher to advise him, and consulting reference books, he satisfied his need to understand the motor in hand. At the same time, the heating unit, which was broken, gave rise to a study of conductivity, resistance, and heat production of the electric current. Material used as insulation of the heating unit called forth an acquaintance with mica and asbestos. The analysis of the connection of motor and heating unit led to the problem of circuits in parallel and in series. Another time a teacher's suggestion that photographic negatives could be printed on leaves stimulated some boys to undertake it. The process mentioned is based on the fact that starch is accumulated in the leaf proportional to the light, which strikes it. A clear negative placed tightly on a banana leaf and left there for twenty-four hours, will cause different assimilation speed and therefore different starch quantities produced under the various densities of the negative. Extraction of the chlorophyll and reaction with a solution of iodine makes the positive picture appear on the leaf. Precaution was necessary, because the starch, which formed in the daytime, is carried away more or less to storage places or needing parts in the night. This consideration suggested, consequently, attaching the negative in the evening and cutting the leaf off the next afternoon, while the light was still bright. Problems involved were photosynthesis, the change from

starch into sugar in order to conduct food, conducting vessels in leaf and stem, cell activity, the test for starch, etc.

Another day a girl brought a newspaper article to class about blood tests and their value for detecting crimes. Why should we not play detectives a little ourselves? We supplied some benzidine and the hydrogenperoxide was in the laboratory. We made several bloodstains with real blood and posterpaints, and tried out the method, with one hundred per cent success. Immediately the question arose: But how can we tell whether it is human blood? This led us to the different size and shape of red blood corpuscles, hemoglobin crystals, and the method of measuring or counting microscopic objects. Or—to mention a last example of activity—I want to tell briefly the story of a group of boys and girls, who, while the rest of the class was studying something else, decided to build an outdoor pool for fish and waterplants. A competition for the design gave enough chance to recall drawing to scale and supplying materials asked for measuring surfaces and volumes to determine the needed quantity of bricks, cement, and sand. In the enthusiasm of the building enterprise, there were, nevertheless, some structural laws of masonry overlooked, which we realized at the end. Nevertheless, the pool has stood now for two years, and besides containing fish, which are in care of younger children, it supplies inside aquaria and provides waterplants and protozoa for the biology class.

These few examples are enough to show you how many things can be learned if the interest arises to do one little thing or to solve one little problem. This process applied in each example is really an age-adequate attempt towards scientific methods and procedures. It is highly analytical and has a precise goal. The value of good reference-books for such work is very great, and an adequate setting in room and material is almost indispensable.

I doubt very much the value of the so-called work books in general science. The filling out of blanks is very soon devaluated to a mechanical procedure. The work is much more vital if the class itself makes up its mind—perhaps in groups—what it wants to do. This leads to fascinating expeditions into the science field, some of which I have tried to picture. It would be worth while to make a comparative study about the quantity and quality of retention of science information after a period of

time, where the students to be tested had been exposed to both methods of general-science teaching.

Several general-science courses of study which I looked over, e.g., from Houston and Atlanta, begin their work with discussions, which I think fit much better at the end than at the beginning of the course. I mean objectives like these: "General Science is organized knowledge of our environment so classified that we may use it in acquiring other knowledge and in more efficient living" or "The Study of Science enables us to understand better the things about us." Abstract considerations like these are outside the mental scope of this age-level. This age wants to do things. In doing them it can not avoid the picking up of generalizations and of scientific methods as I described it in a few instances. But understanding of social implications, as well as cultural values of science, is apt to arise with maturity and has its legitimate place at the adolescent age, to which I want to turn your attention now.

You may have observed that the psychological stages of adolescence or pre-adolescence do not always exactly coincide with the chronological age. Variations are due to different advancement of maturity, the process of which may be delayed or accelerated; it reminds us of the fact that physiological and mental development do not necessarily run parallel. These both need educational assistance to make them as nearly parallel as possible. This can only be done through age-adequate methods and programs based on the psychological characteristics of the learner.

The adolescent is entirely different from his predecessor. The developmental progress from pre-adolescence to adolescence in terms of psychology is the consolidation of the self-controlling system, the "ego" of the individual, and the loosening process of the close ties to the family. The adolescent exchanges the family for a congenial group or society in general. In search for life-patterns, ideals or identifications, he turns his interest beyond the family, usually finding them in the realm of personal acquaintance, in history, science, politics, sports or movies. For the first time the adolescent is deeply concerned with the question of where his place is in society, and whether he is wanted, liked, and accepted. The intellect seems to be broadened and is extremely open to problems of general concern, especially social, biological, psychological, and cultural.

The committee of the Progressive Education Association

which made a study of adolescence, has helped a great deal to clarify this point. This study was undertaken out of the very true consideration that, without an intensive knowledge of the adolescent age, we will never be able to build up an adequate program for it. Unfortunately only part of this study is made public.

Again, we can ask what does educating for life mean in reference to the adolescent. Again two avenues open: one, which is filled with facts and skills which have to be mastered, and the other one, which is full of problems with which the adolescent is concerned and which need clarifying and expression if the school does not abandon its responsibilities. It is obvious that the school has to solve the problem within its framework of instruction and activity. As I see it, the problem can be dealt with only if we consider the dynamic of subject-matter. This conception leads mainly to the discussion of the third point which I want to analyze, though I postpone clarifying its meaning. Instead I want to report several attempts to solve the problem which were or are being carried out in the South.

First I want to mention the summer course of 1936 for teachers which was given at the Alabama Women's College at Montevallo. The educational leadership was in the hands of Dr. Alice Keliher, and the science teacher who taught at the demonstration high school was Mr. W. V. Varnell, Norris School, Norris Dam, Tennessee. Out of the consideration that adolescent boys and girls are eager to fill places of social responsibility, with all the devotion and enthusiasm of this age, and have an urgent desire to undertake work of social importance, the class and the staff looked for a project of such significance in the community. They decided to attack the problem of soil erosion, which was terribly neglected in the surrounding territory.

What did that mean as a science project? It meant learning about soil, the food values of soil, the kinds of soil, understanding the importance of soil erosion and its specific importance for the community they live in. It meant studying prevention, discussing conservation. It meant going on field trips and deciding about a limited locality in which to start the work; mapping the land and measuring grades in order to determine the borderlines of one draining system. It meant planning the preventive steps, carrying stones, mixing concrete, building dams, protecting gullies, discussing the value of forests and reforestation, learning about the value of different crops and their binding value,

about crop rotation and under-ploughing of leguminous plants to bring back nitrogen values to the soil, etc.

Enumerating all the different sides of the work which were actually attacked, I named only half of what was achieved, because I have not yet mentioned the values for character building and personality development, which are at least as important as the dams built and the science facts studied. The cooperative undertaking of a project with decided social importance and creative values for the community colored decidedly the spirit of the group. The students brought information home and informed their parents about vital problems; they discussed them at the dinner table and urged their fathers to join in the work. One week-end when rain was forecast by the weather bureau, they spent the Saturday to finish their work before the rain should arrive, and with greatest excitement they rushed out Monday morning after a Sunday's downpour to see if their dams had held. Imagine the satisfaction and pride to find them in good condition and no soil washed down the hillside as before into the lower pastures. These are situations of real educational values, even if we can not measure them by standardized tests! The returns come invisible and after school, as social responsibility, cooperative spirit and constructive citizenship.

A similar summer school plan was carried out in Ruston, Louisiana Polytechnic Institute. The educational leadership was in the hands of Mr. Ralph E. Boothby from the Metairie Park Country Day School, New Orleans. I was responsible for the high school science work. Without knowing what was going on at the same time in Montevallo, I centered my project also around the soil, taking advantage of the fact that there were in the town the headquarters of the Soil Conservation Service and the Soil Testing Station. I myself tried to incorporate more laboratory chemistry and to arrive at more basic chemical principles applied in the study of soil than my colleague did in Montevallo. I included also a study about soil improvement which led necessarily into biology. An assembly at the end of the study was a welcome occasion to summarize our work and to tell the rest of the school about our findings, experiences of field trips and the work done by the government in the community. It would take too much time if I were to go into more details. I just wanted to mention that two state colleges of the South (Louisiana and Alabama) set up their summer school work in

order to reorganize the high school program and method. With satisfaction I heard that the science teacher who succeeded me after summer school is teaching in the initiated way, breaking away from the chemistry textbook course and the cooking book laboratory manual, using them as reference books like many others.

I have to hurry to bring forth the third and last point which I want to analyze and discuss. I called it, "the inertia of the high school science curriculum." In the National Survey of Secondary Education we can find in the science report the statement regarding Physics, that "Physics courses have not changed since 1910." They even do not take advantage enough of the general science which precedes them. That leads to much overlapping. New textbooks in all the specific sciences are put out constantly, with some minor changes, additions or subtractions; but basically they are simplified college textbooks, which are themselves simplified university textbooks. This leads to the common assumption that high school science teachers are simplified college professors. We could easily complete this comparison down to the new science series for elementary school which are published rapidly at the present time. The basic mistake in this textbook writing approach is to think that a child is an incomplete adult. It is not. It is in itself just as complete and adjusted to its level as an adult is to his. It should be the professional work of a teacher to adjust method and program to the psychological characteristics of each age-level; instead of thinking in terms of content, he has to think rather in terms of general outcomes.

We must also consider that each subject-matter has its specific function for the individual's different needs. That is what I call the dynamic of subject-matter. As an illustration, let me use the senior high school level. Starting with the consideration of the needs of this age, we come to the conclusion that it is mainly concerned with questions concerning its own development, physically and mentally; with questions of sex, sex-relation, family, society, religion, vocation. There are mainly two subject-matter fields which can take the lead in clarifying those problems: biology and social science. So far as biology courses of study are concerned, they are not at all adjusted to this need, but are still simplified knowledge, adult information talking down to a lower level. This attitude is exactly what the adolescent resents in life but accepts at school stoically as a

requirement which will at least pay dividends in terms of credits. If biology courses were arranged age-adequately (which I will discuss in the biology section), they could take care of the immediate age problems and incorporate them constructively into their programs. The result could be seen in the work of other subjects which are more specific and abstract; concentration upon them would be easier, since the distractions from within are cared for and therefore diminished.

Biology could turn over the lead to social science as soon as science study turns to physics or chemistry, which have no direct bearing on adolescent problems. Nevertheless, we can notice in the adolescent a decided pleasure in mastering these sciences, provided another subject takes over the responsibility of meeting the student in the realm of his vital concerns. This substituting of different subject-matter in reference to the inner need of a certain age is what I propose to call the "dynamic of subject-matter."

I think we have to consider this in order to set up a balanced, age-adequate program. We can not make an encyclopedic knowledge the basis for studies by grading it according to ascending difficulty. We have to consider the previous experiences as well as the other subjects and the psychological characteristics of the learner, if we are reorganizing the science program. We can not plan the program of *one* subject separately; they are all dynamically interwoven and play their part in the totality, which is the school. Similar dynamic relations exist at elementary and junior high school levels.

With these considerations which I have just described in mind, I do not think it is absolutely necessary to abandon the more or less academic chemistry and physics courses if social science can meet most of the needs of personal and emotional issues during that time. I even believe that they have a constructive place at this age-level, provided the dynamic of subject-matter is realized, and the program is arranged according to it. But biology needs a basically new approach, and I hope the colleges will soon give us the opportunity to do it. As you know, there already are thirty high schools which enjoy this favored position.

Very interesting in this connection is the last bulletin of the Arkansas Cooperative Program to Improve Instruction. In this plan are the special sciences—as well as other subjects—split up into two courses: one of appreciative and cultural nature,

which everybody is supposed to take as part of the core curriculum; the other course for special interest will care for individual interests and needs and provide for further study in particular fields. On this basis the subject-matter content is not merely more generalized to meet broader life-situations, but is in the special interest course even deepened and concentrated. This attempt to meet the situation reminds me of the European plan of education, where different school types offer the same subjects with different emphasis, according to the vocational training which the student is probably approaching in his later life.

Allow me at the end one brief remark. The school is only a part of social institutions bearing all signs of society's uncertainties and insecurities of its strength and self-confidence on its spiritual face. In discussing problems like the ones of science teaching, we really touch on a problem of much more universal concern. We touch on a cultural problem of the most complex design and become suddenly aware of the intrinsic inter-relation between all cultural factors down to its most unexpected manifestations, like science-teaching. We must sometimes become aware of this determination of our profession in order not to lose ourselves in details of subject-matter. It is exactly this inter-relation or interlocking of all activities and experiences in the school, between the psychology of the respective age-level and the method as well as the program, which I wanted to bring forth in this paper.

I told you in the beginning that this paper does not deal adequately with its title. I hope at least that I have given you an idea of what is done in some localities of the South besides having clarified a few general objectives of science instruction which may help us towards a better adjusted science program.

VIRUS CRYSTALS PRODUCED BY WHIRLING

Protein crystals of the virus responsible for the mosaic disease of tobacco have been prepared by whirling at terrific speed in a centrifuge, instead of the more conventional methods involving chemical treatment and evaporation, by Drs. Ralph W. G. Wyckoff and Robert B. Corey of the Rockefeller Institute for Medical Research.

Clear juice pressed from diseased tobacco plants was centrifuged until a pressure of 40,000 times gravity was produced. Small solid pellets were found in the apparatus, which under the microscope were plainly crystalline in structure. These were compared, by X-ray analysis, with crystals of the mosaic-protein substance obtained in the conventional way, and the ray-patterns thus produced were indistinguishable.

They have reported on their experiments to the journal, *Science.*

AMORALITY IN INDUSTRY*

By Gustave Lippman
Pediatrician, St. Louis, Missouri

Using the term amorality in relation to an aspect of our highly civilized society is a challenge. It calls for an understanding of the term. In my discussion I am using not ethics, not immoral, but amoral for its connotation of the non-recognition of responsibility towards men in their daily intercourse. Especially we will consider it in the development of today's industrial economic system.

Invention after invention have made possible advances and comforts undreamt of even a decade ago. But the dark side of this progress, the loss of health and human life has been relegated to oblivion and little consideration has been given as long as the bookkeeping shows on the black side of the ledger. Now let us look at the difference of the attitude of scientific medicine towards progress.

No thought of patenting the fruit of the laboratories has motivated the medical scientist. His aim has been and is to make humanity healthier and happier, never losing sight of his moral obligation and ethical attitude. Untiring experimentation has resulted in benefits to mankind that are *tested* to safeguard humanity. The experimenter has not spared himself, even has used himself as a human guinea-pig to prove his theories and his treatment without danger to the stricken.

606 was the six hundred and sixth material with which Paul Ehrlich experimented in his small laboratory on Frankfort-am-Main for the eradication of the worst of all social scourges, syphilis. Smoking innumerable cigars, he sat innumerable hours in his laboratory until he could offer the world a sure result from his years of effort. It was a *safe* cure, a free gift with no pecuniary reward expected.

Millions have been made in the manufacture and distribution of 606. Paul Ehrlich died a poor man. Let me recall another page in medical history that is probably known to you but not possibly with the connotations I wish to emphasize. Dr. Walter Reed carried on heroic work to find the cause and rid the world of yellow fever. Three of his collaborators lived in a house specially constructed to shut out the sunlight and fresh air, filled with

* Read before the annual meeting of the Central Association of Science and Mathematics Teachers' St. Louis, Mo., Nov. 28, 1936.

boxes of sheets, pillow slips and blankets contaminated by contact with cases of yellow fever and its discharges. For twenty days they lived in this room, unpacking the boxes each night, packing them each morning. Using themselves as the guinea-pigs they completely discredited the earlier belief that the transmission of yellow fever was by fomites.

Thanks to Reed and his commission it was conclusively proven that the disease is transmitted by a mosquito. What this has meant to the western hemisphere can not be expressed in dollars and cents. Panama was cleared of yellow fever by Colonel Gorgas by eradicating the mosquito. And the southern states of our country freed from this terrific threat were made safe for habitation. Cities like New Orleans and Memphis developed into prosperous modern communities—the south came into untold riches—and Walter Reed's widow had to beg the government for support and received a mere pittance.

If Professor Roentgen had patented the results of his experiments with the x-ray untold riches would have come to him, would still be coming to his heirs. In the development and perfection of this life saving procedure, hundreds of doctors died a slow death of cancer produced by the burns of the ray. On their own bodies they had to learn the correct dosage before the safety zone was found—by medical science and their names remain unmentioned on the honor rolls.

The University of Wisconsin's, Harry Steenbock, found the means to enrich the Vitamin D content of foodstuffs. He worked out a process for the irradiation of ergosterol and lipoid substances. The commercial value of any inventor of this process would have been enormous as anyone may judge from the flood of advertising on Vitamin rich foods. But what do we see? Instead of using his invention for personal profit, Dr. Steenbock who obtained the patent for his process turned the rights over to the Wisconsin Alumni Research Foundation. The huge income that is annually derived from the patent is returned to the public in the form of service for its benefit. The Foundation uses it for the promoting of scientific research, for further aiding mankind through new discoveries.

In laboratories the world over new drugs are being developed which promise certain results in combating disease. And many a drug that promised excellent results in early experimentation was discarded in the laboratory because it could not pass all the painstaking tests which are demanded before the scientist

offers it to the profession. The drug may give the desired results but inherent qualities may present dangers which offset its value.

These few examples are typical of the pages of medical history—evidence of the ethics of a science that has kept control of the means toward the end it seeks. The ethical concept which has been inherent in the spirit of the experimenters in medicine working for the betterment of mankind—this ethical concept is the fundamental condition of its progress. The profit motive and the speed up which characterize many aspects of present day progress obviously have no place in the medical research laboratories that dot the world. Think of radium—it is an excellent example to use as a connecting link between what I have had to say about medicine and what I shall say about the use of science in industry. In medicine marvelous cures in cancer were produced once its potential dangers were known. On the other hand the sharp business mind set its research laboratories to work to capitalize on the phosphorescence of radium. We all know the results, a way to use radium as paint for the dial of clocks and watches. No thought was given to the possible consequences. Once the laboratory had discovered a result it felt no obligation toward probing the procedures and effects of the method. Girls who worked in the factories used saliva rather than water to get the necessary fine tip on their paint brushes for the delicate work of marking the numerals and hands. Burns and cancers with a horrible slow death were the result. The company fought the damage suits in the courts. Lives that cost money turned the companies to set the laboratories to work now for a safe method for phosphorescent dials. The inventors —does anyone ever consider the possibilities of bringing the charge of manslaughter against them.

Progress in industrial development have meant continual search for new ways and means of fulfilling ever new demands. Chemical and physical sciences have been called in to aid in this progress. The few examples I have given are certainly known to you. But practically unknown are many other industrial diseases, certainly many of the ramifications are not considered. The harm done by the use of carbon tetrachloride in the laundries is an obscure disease produced in the girls that handle the water to which this drug has been added. No experiments were carried on before its use and it has fallen to medical science to prove it effected irreparable damage to the lives of

the workers. Now medical science is taking the responsibility of finding the way of making the industrial procedure safe.

Lead poisoning was an accepted result in industry for many years. It took the hand of the government to force industries to overcome this scourge in the production of paint. While the sanitary methods forced on the big industrial concerns alleviated the possibilities of lead poisoning, they did not affect the home workers who made lead soldiers on consignment for the toy concerns. Whole families in their homes are attacked by this poisoning which is practically incurable. Why these victims of industrial progress?

Those of you who are old enough remember the tell tale odor of the phosphorous match. The use of phosphorous in the match industry carried with it the most serious consequences. The worker was attacked by necrosis of the bone and the phosphor jaw became a land mark of the industry. Was the machinery stopped when the first cases of this dread disease were recognized? Again it was the hand of the government that had to forbid the procedure that was taking its toll of lives by outlawing the use of pure phosphorus in industry. Damage suits and the law forced this industry to use its resources for the production of a safe and sane match.

Hundreds of workers every year become the victims of an infection from the anthrax bacillus in the fur and hide industries. It is impossible for the worker to safeguard himself—why should not this industry devote at least some of its profits to overcome this disease which has so far baffled preventive medicine? We have been talking in terms of the human lives that are sacrificed to industry. And we cannot omit the story of silicosis which reappears continually in the newspapers. In the dustfilled tunnels the workers inhale the fine dust of silica. Slowly the fine air vesicles of the lungs are closed up causing a chronic disease silicosis which is usually followed by a tuberculosis. Whole mining communities have been wiped out by this disease and thousands of Americans today are doomed to certain death because of their honest toil in industry. The chronicity of this disease makes it possible for the legal talent employed by the industry to fight the well deserved damaged suit of the worker. A positive diagnosis of the worker by the physician in the early stages is practically impossible because of the insidious beginning and the slow development of silicosis tuberculosis. Until the x-ray picture shows the shadow in the

lungs and the worker is well on the way toward death, definite proof is almost impossible.

It must be put on the doorsteps of industry to reckon the lives of its workers on its debit sheet and find a means to make its profit without such cost. The prevention of this disease at its source is made possible today by exhaust pumps and wetting. But millions are being spent in fighting damage suits; how much for effective prevention?

The pages of the history of industry are bright with its achievements in making man the master of his environment, offering him new worlds in comfort, convenience and happiness. Daily the press and the demi-scientific journals herald the introduction of new means to further WHAT? We come now to the serious dilemma in our industrial progress. What have we a right to expect in our industrial life from the scientific support on which this life is built. Should we not be able to take for granted the same ethics in commerce and industry which we demand from medicine? "Nil nocere"—No harm may come of it—this is the prime demand made to the introduction of each new method in industry.

What driving force spurs industry to enlarge its scope? How closely allied are progress and profit? What of the havoc to the lives of the workers through whom profit has been made from progress? Obviously the machine is without conscience, without ethics—what of the man who controls it? We challenge him as a modern example of amorality. We are willing to agree that, in his daily life and his commercial intercourse, he is not with intention immoral. His lack of consideration of all ethical concepts shows the blind spot in an otherwise enlightened person. The head hunter savage whose fortune is in skulls; and those tribes which show no feeling for human life by starving the members of their community who have outlived their practical usefulness—are considered amoral by the civilized world. If we are consistent the owner of the mine whose fortune is built on the tombs of silicosis victims—can we call him other than amoral. Modern production plants based on the belt and conveyor system burn up the energy of men in three to five years, forcing them down to the lowest levels of earning and living standards. It is known that certain of these plants enticed to their employment the hardier youth from the country in preference to city people whose nerves break even sooner under the strain. While we watched Charlie Chaplin's latest picture "Modern Times" did

we feel it as a challenge to the masters of industry for its truthful depiction. Grant this recognition of a picture that dressed deep human pathos in humor and the term amoral and its relation to industry must be changed to immoral.

The latest challenge to the industrial age lies in the change from amoral to immoral. In its rapid development it could scarcely be held culpable for its wrongs. Neither the government nor the public at large expected industry, which was intent upon increasing its output, to feel any responsibility in its selection of methods of procedure. A few so-called cranks and some social service workers lifted their small voices against the din of the machine. But on the whole, no obligation beyond that of manufacture was expected of the industrialist. His power carried with it no obligation to humanity.

The time to claim amorality for industry is gone. Today its evils are being brought to its attention in the press and the magazines, on the stage and in the motion picture. It can no longer excuse itself on the basis of paying money to the wreckage it leaves in its wake. The day of the damage suit conscience fund must go.

Medicine gives a concrete example to industry on how it can avoid progress without ethics. It must learn a new approach in its undertakings. Before introducing a new method there must be consideration for the health of the workers and any method that carries inherent dangers must not be effected even should its results mean greater profits and dividends.

An amusing sidelight on the Janus-faced aspect of industry is the establishment of the Nobel prize bequest for Peace. Nobel's fortune was founded on the manufacture of killing materials—a part of his fortune is now given for the outstanding worker in the promotion of peace. And today that country which is most intent on manufacturing those products which brought Nobel his fortune, will not allow a famous peace exponent to accept the conscience fund that Nobel established.

The Carnegie Institute, the Rockefeller Institute and many other similarly endowed foundations might possibly be called the conscience funds of industry, bridging from an amoral over an immoral to an ethical attitude. A great part of the work of these foundations if carried on today in finding cures for the industrial and economic diseases which might not be necessary had industry in the beginning felt its obligation to the general weal. Again let me bring in medicine with a homely old quota-

tion—"an ounce of prevention is worth a pound of cure."

And in thinking of the possible means for prevention, I chose this theme for you, the teachers of science and mathematics. You are introducing your students to the tenets of science and to the brilliant possibilities for a future that industry offers them. You strike the spark of youth's enthusiasm by showing them the lives and accomplishments of the great engineers and inventors whose experiments have made the machine age possible. You are educating them to further that progress. How do you define success to your students? Is there a study on ethics in industry in the curriculum of the engineering department—a chapter on social outlook in your science textbooks? You have the industrialists of tomorrow in your hands now and partly the awakening of their moral sense rests on your shoulders. You yourselves must see beyond the accomplishments of progress in production—so that industry will face its obligations. No blind spot tomorrow.

MOSELY (1888–1915)

By Sr. M. Agnese
St. Joseph's High School, Fremont, Ohio

"The whole history of science shows that it is to the worker that the inspiration comes, and that new ideas develop from old ideas."[1] Nowhere is this more evident than in the young Englishman, who at the age of twenty-six gave to the world in 1912 his law of Atomic Numbers.

Henry Gwyn Jeffreys Mosely, son of Henry Nottidge Mosely, Oxford Professor, was left at the age of four, entirely to the care of his wonderful mother. His life and experiences at school differed in no way from those of an ordinary English boy. He had a genius for mathematics, a great boon for him in his later researches. He also succeeded brilliantly in the classics. In fact, he had a large portion of the intellectual gifts which had made his ancestors, both paternal and maternal, outstanding in scholastic achievements.

Ernest Rutherford at Manchester, recognizing the born investigator in the youthful genius, suggested radioactivity as a definite line of work for young Mosely's research. His mother encouraged him in his gigantic research work. Mosely worked tirelessly in his laboratory, often turning night into day, and in six months he completed his vast work.

In 1914 came the call to arms. June 13, 1915 Mosely was on his way to the front. His letters to his mother breathed only cheer—it was characteristic of him to write nothing of the dreadful carnage of war to her who had been his inspiration. It was his fate to accomplish in his youth, work of surprising importance. Suddenly in August 1915, his young life was terminated by a Turkish bullet. Before the world heard of him, Henry Mosely was no more. But the world has heard much of him since.

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[1] Libby, W. History of Science. New York: Houghton Mifflin Company, 1917. P. 268.

ON THE ROLE OF GEOMETRY IN SCIENCE*

By Frank W. Bubb
Washington University, St. Louis, Missouri

I wish to explain how geometry guides—one can even say dictates—the development of natural science.

In presenting this thesis, I must call attention to certain aspects of geometry not commonly emphasized. Geometry is usually regarded as a measure of external space. In popular conception this body of knowledge is supposed to have been put into permanent form by a Greek gentleman named Euclid. Both of these beliefs are entirely untrue.

Our knowledge of space is obtained through the senses. The sensory apparatus may be likened unto a lens system which throws upon the mind an image of external space. Geometry is our knowledge of this mental image, and this internal picture may or may not be a faithful reproduction of external space. I shall show from historical evidence that geometry has, during the last two thousand years, undergone some startling changes. Now surely it is easier to believe that these changes have occurred in our conceptions of space rather than in external space itself.

I think I had better try to impress upon you more clearly the distinction between external space and these several internal or mental images thereof. I can make my meaning clear if you will perform an experiment with me. Close your eyes (after a moment) and imagine or visualize yourself standing, say, before your own home. Enter your house, in imagination, and walk through the various rooms, noting their arrangement as well as that of the furniture. You may indulge your fancy a bit by rearranging the furniture. You will quite miss the point of our experiment unless you stop long enough . . . to exercise thus your space intuition. You may picture internally in this manner any familiar scenes, persons, and events. You may dramatize your past and attempt to visualize your future. It is this power of the mind to construct pictures (of the lovely heroine, for example) which enables you to enjoy reading books. Without this power, you could not betake yourself from your work to your home in the evening: it would be unsafe for you

* Address before the Physics Section of the Central Association of Science and Mathematics Teachers. St. Louis, Mo., November 27, 1936.

to go anywhere beyond your immediate range of eyesight. You can (and if you performed the experiment proposed above, you did) visualize a distant scene so vividly that you are bewildered for a moment upon coming out of such trance-like state. Then is the time to ask yourself where is that place in which you seemed to be but a moment ago. You were not in that distant place itself—if you have an astral double, it may have gone there, but certainly your body did not. Neither is that place inside your head: your head is not large enough to hold that house. But there certainly is something inside your head corresponding to external space. This is what I call the mental picture frame. This is the internal filing cabinet wherein we store our perceptions. This is the seat of our visual memory. This is the laboratory wherein we make our mental constructs, develop and fit together those abstractions called the concepts of science.

Is the internal picture frame, which a person may have, a faithful representation of external space? I shall let you judge of this by actual example.

The ancients, before the time of Euclid, had a 2-and-1 geometry. They conceived all horizontal directions to be alike, thus forming a homogeneous 2-dimensional manifold. But the one vertical direction was conceived to be unique and different in nature from any of the horizontal directions. Gravitation was so universal a phenomena that apparently it was not thought necessary to explain it—gravitation was simply part of the uniqueness of the vertical.

Children seem naturally to form this 2-and-1 conception of space—a matter which may be verified by conversation with almost any little person who has competence in self-expression. I had a most interesting talk with one little chap who was hearing for the first time that the Earth is spherical. He objected at once, pointing out to me the fact that the vertical *is* different than the horizontal. He wanted to know how people on the opposite side of the Earth cling on to its surface, why they do not start sliding when they journey too far, why the oceans have not run off, and demanded the why-nots of certain other phenomena which his imagination led him to expect. In short, by the simple device of extrapolating the vertical parallel to itself, he proceeded in masterly fashion to demolish my absurd notions on the sphericity of the Earth. And to clinch the argument, he challenged me to step off the roof and test the essential correct-

ness of his views. I am having a slight measure of success in persuading this small Newton that his assumption that all verticals are parallel does not agree with experience.

The ancients extended this local horizontal-vertical partition of space to the uttermost limits, and consequently supposed the Earth to be flat—as children do. Upon the seas, mariners feared to sail too far lest they go over the edge into the bottomless abyss of space. Sailors who failed to return were commonly supposed to have perished thus.

Such a flat world had to be supported—somehow. To perform this function, the orientals posted an elephant at each one of the four corners. But this is not enough. Some scientifically minded fellow, lacking in respect for his ancestors, eventually raised the question as to what the elephants stand upon. The question cried as logically for answer as the original question concerning what supported the Earth. The question was answered by asserting that the four elephants stand upon the back of a turtle—a sturdy turtle. But the question recurs and the suite of answers caused the foundations of the Earth to take on resemblance to a totem pole.

This question as to the foundations of the Earth is important because it provides a perfect example of how growing science disposes of some quite logically formulated questions. Science has never answered the question as to what supports the Earth —it quietly murdered the question—made it nonsense. The question as to how empty space transmits the enormous gravitational force between Earth and Moon is of this category. This gravitational problem, which has produced since the time of Newton some 200 theories (at least 199 of which must be wrong) as to means of transmission, is not answered by relativity: it is simply removed—the force does not exist. And there are doubtless numerous questions now tormenting us poor humans which have intrinsically no meaning—no matter how logically they may now appear to demand answers.

The common device for explaining natural phenomena in the ancient 2-and-1 cosmogony was the nature-myth. Rivers flowed because local river-gods pushed the waters along. The Sun rolled across the heavens because it was dragged by the chariot of a mythological being. The winds were controlled by angels who stood at the four corners of the Earth. Heaven above, hell below, and the Earth between were filled, each with a diversity of gods and demons: Zeus with his thunderbolts, Pluto with

his fires, and Poseidon with his storms. Greece is still dotted with the ruins of temples dedicated to their propitiation. Natural phenomena occurred or did not occur according to the caprice of gods and demons. The nature-myths peopled the Earth, the skies, and the seas with living beings, as senseless and savage as those who framed them.

What was this 2-and-1 Geometry? We now regard it as a distorted mental image of space. This affords an example of the point I made above that Geometry is our knowledge, not directly of external space, but of the internal space image. For, surely no one except children now regards external space as actually shaped according to this ancient model.

There can be little doubt that our conception of space is intimately bound up with the particular sensory equipment which humans happen to possess. Now the problem of perception is given little attention by the scientist in spite of the emphasis placed upon it by the philosopher and psychologist.

Let us examine, if only for a brief moment, the sensory equipment of the natural philosopher. He is endowed with five senses which enable him to partake, slightly, in the profound actions of natural forces. He can not participate intimately in chemical reactions: he can not be dissolved, go colloidal, or explode. Perhaps he might do one of these things but his knowledge of what had happened to him would not be available to the rest of us. He can not indulge with too much abandon any taste which he may have for thermodynamics—he might be gassified one way or solidified the other. He can not personally commune with lightning flashes. In short, he is careful to stand well away from and intrude himself only with circumspection into the affairs of nature. Most of what he knows has not come to him through his sensory channels; he has invented most of it. His senses are like the pinhole of a pinhole camera. Through this pinhole, he peers out at the world. And just how tiny this pinhole is, is rather frightening—makes one feel like a child lost in the dark when one realizes the vast extent of the reality which one seems barred from ever perceiving directly.

How, in view of this, can one believe that the external world is shaped the way we now conceive it to be? Or to put the same question differently, how can we expect the mind to construct within the convolutions of the brain a framework which shall be a faithful representation of the external world? Isn't it possible that space-time is just our mode of thinking about external

phenomena? Do we not externalize this way of arranging our perceptions and conceptions and superimpose this framework upon the external world? The historical evidence that Geometry has changed, altho, alas! with evolutionary slowness, is positive evidence for this view.

I shall anticipate here a question which someone is sure to ask. If one should train oneself to think with facility in four dimensions when one is young and before one begins to believe the external world is three-dimensional, namely, if one were to develop systematically a mental four-dimensional framework, would one then externalize this mode of thought and regard the external world as four-dimensional? I think so. Unfortunately I studied the properties of four-dimensional figures after I was taught to regard the external world as three-dimensional. But in spite of this handicap, I occasionally glimpse relations which can not be expressed in three dimensions.

But let us return for a moment to the ancient 2-and-1 geometry. In this framework, gods and demons were regarded as the efficient causes of things. Mythologies, which are now regarded as nothing more than poetic fancies, were then both the science and religion of their times. Nature-myths were the explanations of natural forces. They were attempts at rationalizing natural phenomena. And that is precisely the purpose of any of the accepted theories of modern physics.

Such was the grotesque scientific picture which our ancient brethren painted in their 2-and-1 picture frame. But within such a distorted, poorly shaped frame, how could anyone paint other than a fantastic picture?

The next frame for our mental picture of the universe was constructed by Thales, Pythagorus, Euclid and others. We shall call this the homogeneous 3-frame because all directions in space were conceived to be alike in geometric properties. This homogeneous 3-geometry makes room for a spherical Earth. In this enlarged frame, the 2-and-1 geometry appears as an unwarranted extension of the local horizontal-vertical partition, which we make of space. The 3-frame permits individuals at different points upon the Earth to make their own local horizontal-vertical partition—as each individual will if he wishes to keep head-end up.

In this picture frame which goes by the name of Euclidean Geometry, many artists have wrought. Isaac Newton nearly filled the picture with his cosmic theory, a stupendous structure.

Magnificent designs such as Maxwell's electromagnetic theory endow the picture with life. The radiant patterns of Fresnel and Michelson, of incredible delicacy, transcendent beauty, adorn this wonderful picture. This is no dead thing wrought in metal, painted on canvas, or cut in stone to catch a fleeting mood: this is a representation of nature herself. Its beauty consists in the play of intelligence upon matter, spirit upon energy, and the scientist is an artist vastly more subtle than the greasy fellow who smears paint upon canvas. His creations are so convincing that he frequently fools himself into believing that he has grasped reality itself instead of an image thereof.

In order to show what I mean by the assertion that geometry dictates the form and content of scientific concepts, I shall become a bit technical. I make the point by discussing a bit critically the simplest of the physical sciences, statics. This branch of mechanics consists of four basic items.

(1) The Concept of Force. In our recurring groups of muscular sensations, we find the thing we call force and in it the properties of direction, magnitude, and position. To construct a geometric image of force, we draw a line through the point of application of the force, in the direction of the force, make its length equal to the magnitude of the force to some arbitrary scale of length, and place an arrow on the line to indicate the sense of the force one way or the other. So far as statics is concerned, we assert that such a directed line or vector is a perfect symbol of force.

As a matter of fact, there are many properties of force which this geometric symbol is incapable of depicting. For example, a force never acts at a point but is always distributed over a finite area. There is nothing about the vector to indicate for how long a time the force may be applied, whether it be moving or at rest, whether it be applied with kindly or malicious intent; yet a force which is moving and doing work is quite different than a force which does no work. However, we end this quibbling by defining statics as that branch of mechanics which concerns itself only with those properties of force which are represented by the vector symbol.

(2) The Moment of a Force. The moment of a force about a point is represented by and thought about in terms of precisely the same geometric symbol we use to represent force, the vector or directed straight line segment. The moment vector is constructed as follows. Pass a plane through the point in question

and the line of action of the force. Through the point erect a line perpendicular to this plane: this line is called the moment axis. Lay off along this moment axis a length equal, on any arbitrary scale, to the product of the force by its moment arm or perpendicular distance from the point to the line of the force. Place an arrow on this moment vector to indicate the sense of the turning moment, clockwise or counter-clockwise.

Moment is a derived concept. The fundamental concept, formulated from experience and intelligible only in terms of experience, is force.

(3) The First Law of Statics. If a body be in equilibrium under the action of a number of forces, the vector sum of these forces is zero, namely, if the vectors be put by parallel translation into a concurrent chain, the end of the last vector in the chain coincides with the origin of the first. This law is a generalization from experience. It is sometimes called the parallelogram law.

(4) The Second Law of Statics. If a body be in equilibrium under the action of a number of forces, the vector sum of the moment vectors constructed through any point in space is zero. This law is a generalization from experiment. It is also called the principle of moments.

These four items plus Euclidean geometry constitute the science of statics. These four items are obviously geometrical: they fit the Euclidean frame. There is no problem, theorem, or method in statics, however it may be disguised analytically, which is not geometrical or which may not be made so.

Other classical sciences are likewise geometrical in structure. Most of them are more complicated than statics. For example, the Lorentzian formulation of electricity and magnetism employs six scalar or one-component quantities, eight vector or three-component quantities, and two dyadic or nine-component quantities. These are connected by some fifteen equations in the nature of defining relations or experimental laws. They geometrize electricity and magnetism quite as completely as the four fundamentals of statics geometrize that science.

In fact, we may summarize the structure of classical science quite briefly. The concepts, the things we call causes and effects, of classical science fall into a regular hierarchy of geometric figures called tensors. The simplest of these is the tensor of rank zero or the scalar having one component such as mass, temperature, energy, action, entropy. The next is the tensor

of rank one or the vector having three components such as force, moment, velocity, acceleration. Then comes the second order tensor or dyadic having nine components such as the inertia dyadic used in rigid dynamics and consisting of the moments and products of inertia of a rigid body. The nine stresses at a point in an elastic body make a dyadic and so do the nine strains at that point. The hierarchy continues with the numbers of components mounting in powers of three—thus the 81 elastic constants required to express Hooke's linear relation between stresses and strains make a fourth order tensor (altho the number of independent components is reduced to about one fourth that number by symmetrical properties of the stress and strain dyadics.) All these conceptual forms are represented by characteristic geometric figures. Thus the first order tensor is represented by a directed line segment. The second order tensor is represented by a second degree surface, such as stress, strain, and momental ellipsoids. This explains what I mean by saying that the form or structure of the concepts of classical science are made to fit into the Euclidean picture frame.

The manner in which the fundamental concepts of a science connect with our experience is the vital part of science. The marvelous accuracy with which our abstractions, our thought symbols, fit upon and describe experience, the exactness, completeness, and artistry with which we frame the basic concepts of a science—this part which is not a matter of reason alone, is the part which grips our imagination, satisfies and awakens the creative instinct. And it is in just these things, these roots which lie below the reach of reason, which are grasped only by the intuition or artistic appreciation, that a science has its most intimate contact with reality. And we seek, as Alexis Carrel puts it in his book "Man the Unknown," in the external world only those things which may be geometrized—and geometry is, in all probability, a thing not of the external world but a thing within ourselves.

The pretensions of the ancient 2-and-1 mythology stand discredited—no one believes any longer in Zeus. The homogeneous 3-dimensional picture called classical physics is now in its turn becoming discredited under the attacks of the quantum and relativity theories. It was, no doubt, difficult for our forebears to abandon their faith in nature-myths and accept the classical picture of nature. The effect of mass faith is not only to inhibit original thinking but to punish quickly such a breech of man-

ners. Socrates and Aristotle both poisoned themselves to escape the consequences of having denied the nature-myths of ancient Greece. It will be difficult for many scientists of the present day to abandon their faith in the Euclidean-Newtonian myths.

Is it necessary to put one's faith in any science? Is it even desirable? Surely the history of science shows it to be a man-made and continually changing scheme for thinking about nature. If one scheme works well, let us praise the artist who conceives the scheme. But it is unsafe and unfair to bind the next generation in the bonds of faith and prevent the construction of a better picture. Why should we not be taught to regard science as a game, leaving out, as the mathematician does, the element of faith.

I shall cite one, among many possible, series of modern scientific nature-myths.

Not many years ago, perhaps not beyond the memory of some of you, electricity was regarded as a sort of "fluidic virtue." For more than two hundred years a controversy raged as to whether there were two electrical fluids or only one. Then came the discovery of the electron by J. J. Thomson. He conceived it to be a tiny sphere of negative electricity. The objections of some of his contemporaries that this conception was impossible because such an electron ought to explode under its own inverse square law of repulsion were gradually silenced by the success of the conception although the question, as a matter of fact was never met. Some ten years or so ago the electron, in the hands of Schroedinger, expanded in the most astounding fashion from a mere concentrated speck until each individual electron filled the whole universe. If one may still apply the definite article to such a conception, *the* electron operated through a mysterious function called ψ, the square of whose absolute value was vaguely reminiscent of charge density, but whose principle duty was to remain finite, single-valued, to vanish at infinity, and be quadratically integrable. This view of the electron as a mass of waves filling the whole universe again underwent modification. The newer view, proposed by Max Born and Norbert Weiner, associates ψ with a probability. Thus, one is free to form practically any picture one may fancy of the electron itself, but one must agree that ψ times its conjugate complex $\bar{\psi}$ is the local probability that the electron, whatever the thing may be, is somewhere about. In these ψ spaces, one part keeps in touch with another by means of little messengers

whose essence was described by the term probability packets. These packets of perhaps or maybe travelled hither and yon on the business of the atom. Now I submit that there is nothing in the ancient mythologies or even in Saint John's Revelations to match these ideas for sheer fantasy. Those conceptions quite surpass that transcendental operation whereby Lewis Carrol detached the grin from the Cheshire Cat. My practical point here in citing this example is that all these conflicting conceptions can not be right—yet some or all of us have believed them. I think we could have played the game just as well without believing in anything more than the convenience of these conceptions.

The most effective means of showing the scientific apprentice that his science is a man-made scheme for thinking about nature is to make him read sympathetically the history of science. He will discover that the causes which man has found or thinks he has found operative in nature are pure romance. He will find that certain facts and mathematical formulae stand out like rocks but that those things he calls causes, those things which for the moment make the picture intelligible, are naught but shifting sands formed by his fancy into all sorts of fantastic figures. Thus he will find out for himself that the Ptolemaic theory of the heavens was a beautiful theory and that it worked. He finds that Carnot derived the second law of thermodynamics from the old phlogiston theory of heat, and that this law not only worked then, but continues in good standing. He finds that river-gods pushed water along in the rivers until Isaac Newton invented the gravitational force. He now finds that rivers flow because of the curvature of space-time. There is reason to believe in the efficiency of Einstein's space-time curvature; there was reason to believe in the efficiency of Newton's gravitational force; and, in spite of the fact that a river-god does not fit nicely into an equation, he was, at least, sufficient cause for the water's motion. Why should one believe in the reality of any of these "causes" just because they fit into the picture? Surely the only reasonable requirement of a picture is that it possess realism—likeness to reality.

Before passing on to a discussion of the latest conceptions of space-time, I must point out certain limitations of the time concept as it is used in the classical theories.

The role which time plays in science developed slowly. The recurrence of night and day and the regular procession of the

seasons must have impressed themselves upon man very early. But the first effective use of time in the present mechanical (and not astronomical) sense appears to have been made by Galileo, who in 1581 timed with his pulse the swing of a lamp in the Cathedral of Pisa, and discovered that its period was independent of its amplitude of swing. Certainly he made effective use of his discovery, for by employing the principle of the pendulum, he constructed an accurate clock and by its use discovered the laws of falling bodies. Upon this reasonably firm foundation, the science of mechanics developed rapidly, particularly in the hands of Newton. And with the basic science of mechanics established, the classical picture was rapidly sketched in as to its broad outlines. Incidentally, the homogeneous 3-geometry of Euclid passed over gradually into a 3-and-1 manifold, 3-space and 1-time.

According to Newton, "Absolute, true, and mathematical time flows in itself and in virtue of its nature uniformly and without reference to any external object whatsoever." All motions may be accelerated or retarded, but the flow of time can not be changed. The same measure of persistence and duration applies to all things whether their motions be rapid or slow. If the progress of everything in the universe were exactly reversed, the flow of time would be unaffected. In other words, throughout its vast extent, all events in the universe click with our little whirligigs, they always have marched to the tune of our clocks, are now so marching, and will always do so: the little whirligig is the pulse of and runs the universe. One is reminded of Rostand's chanticleer whose crowing is the Sun's signal every morning to arise.

It is not possible that this unique, absolute, and universal time coextensive throughout the universe may be merely an extension, purely imaginary as to its reality, of our local time —comparable to the extension throughout all space of the local vertical made by the ancients? The answer to this question gives us our next picture of the universe.

Hermann Minkowski, in a notable address entitled, "Raum und Zeit" delivered to the Cologne meeting of the Scientific Congress in 1908 sketched in broad outline the new picture frame. He seized upon a peculiar interpretation which Einstein had made of certain experimental results due to Michelson, Fizeau, Trouton and Noble, Rayleigh and Brace, H. A. Wilson, and others, all of which exhibited a certain family failing in re-

fusing to live up to the requirements of classical science. Without going into details of this family failing, we may say briefly that Minkowski advanced cogent reasons for suggesting that a homogeneous 4-geometry of space-time might work better than the 3-and-1 space-time of the classical theory. He suggested that the local classical partition, space-time, had been extended too far. Time is undoubtedly experimentally distinguishable from space locally, just as the vertical is locally distinguishable from the horizontal. But just as the vertical at a point, say, on Mars is not the same as the local vertical, so may the time at that point on Mars be not the same as the local time. I quote from Minkowski's lecture: "In nature all is given; for her the past and future do not exist; she is the eternal present; she has no limits, either of space or of time. Changes are proceeding in individuals and correspond to their displacements upon world-ways in a 4-dimensional eternal and limitless manifold. These concepts in the region of philosophical thought will produce a revolution considerably greater than that caused by the displacement of the Earth from the center of the universe by Copernicus."

The essential features underlying both Einstein's special and his general relativity theories was pointed out nearly a century ago, in 1854 by Bernard Riemann in his doctor's thesis, "On the Hypotheses which Lie at the Foundation of Geometry." Riemann noted that the propositions of Euclid may be divided into two classes: those having to do with numbers, ratios, measurements, and on the other hand those having nothing to do with these matters. All propositions having to do with measurements are called metrical propositions, and are, one and all, dependent upon the theorem of Pythagorus to the effect that the sum of the squares of the legs of a right triangle equals the square of its hypotenuse. That part of geometry, exclusive of metrical propositions is called affine geometry. This part, affine geometry, is common to all geometries, and the various geometries differ only in the metrical propositions. Before proceeding to lay down his various types of geometries, Riemann interchanged the Theorem of Pythagorus and the Parallel Postulate, that is, he elevated the 47th proposition, called the "Bridge of Asses" by the British, to the rank of axiom and relegated the Parallel Postulate to the status of a theorem in Euclidean geometry. The new axiom is called the metrical axiom. Hence, according to Riemann, geometries differ only in their metrical

axioms. Inasmuch as the metrical axiom is logically independent of, namely, can not be deduced from, the metrical axioms, he pointed out that we might assume any other metrical axiom and obtain a geometry as logically consistent as that of Euclid. The three types of geometries, elliptic, Euclidean, and hyperbolic, are characterized by the assertions that the sum of the squares on the legs of a right triangle are greater than, equal to, and less than the square on the hypotenuse.

We usually characterize Euclidean geometry by the Cartesian quadratic form, $dx^2+dy^2=ds^2$, where dx, dy are the legs and ds the hypotenuse of a right triangle, occasionally by the plane polar quadratic form $ds^2=dr^2+r^2d\theta^2$, and on rare occasions by more complicated coordinates. All these forms characterize the same flat Euclidean geometry, for anyone of the forms may, by a continuous coordinate transformation, be carried over into another. However, the rather simple quadratic form $ds^2=a^2d\theta^2+a^2\sin^2\theta d\psi^2$, which belongs to a sphere of radius a, can not by any continuous transformation be expressed in any of the above forms—this, incidentally, is the reason why a sphere cannot be rolled out upon a plane without altering lengths, angles, and areas. The last quadratic form is the axiom of 2-dimensional spherical geometry. In this geometry, the sum of the interior angles of a right triangle exceeds two right angles; it is impossible to pass through a given point a line parallel to a given line; two straight lines (straight in the precise sense in which straight line is defined in Euclid, namely, as being the shortest line connecting two points on the sphere) intersect in two points; together with many other propositions which are false in Euclidean plane geometry. Geometries of this kind are called curved or non-Euclidean geometries.

I shall discuss briefly the special relativity theory. The fundamental element in Euclidean geometry is, of course, the point. In the new space-time 4-dimensional geometry, the fundamental element is the event. An event occurs when something happens at a particular point (of Cartesian coordinates x, y, z, say) at a particular time, t. Thus the event has four coordinates, x, y, z, t. The interval between two events x_1, y_1, z_1, t_1 and x_2, y_2, z_2, t_2 may be written as $dx=x_1-x_2$, $dy=y_1-y_2$, $dz=z_1-z_2$, $dt=t_1-t_2$. The new metrical axiom adopted by Einstein, asserts that two different observers (ourselves and our friend on Mars) agree on the quantity $ds^2=dx^2+dy^2+dz^2-c^2dt^2=dx'^2+dy'^2+dz'^2-c^2\,dt'^2$, where c is the velocity of light. Either one of the sides of this

equation is called ds^2, and ds is called the space-time interval. The appropriateness of the name is apparent, since the quantity is obviously a combination of length and time.

Since the two observers previously agreed both on the space part and the time part of the interval, this generalization seems mild enough. However, it commits plain murder upon the time-honored notions of Euclid, Galileo, and Newton; for, it now permits them to disagree on both the time and the space parts, and only requires them to agree on the space-time interval. Furthermore it requires that all the concepts of natural science be reshaped to fit the new picture frame. One or two examples will suffice to show this effect.

Obviously a vector can no longer have only three components; it must have four if it is to be made in imitation of the new four-component space-time interval. If not, it will not fit the new picture frame. Thus, our old friend, the 3-vector momentum mv_x, mv_y, mv_z, takes on a fourth or time-component, mc, where m is the mass and c is the velocity of light.* Two different observers must agree on the quantity

$$(mv_x)^2+(mv_y)^2+(mv_z)^2-(mc)^2=(m'v'_x)^2+(m'v'_y)^2+(m'v')^2 -(m'c)^2.$$

In particular, suppose the primed observer to be moving with the mass m': he gets zero for his estimate of the velocity, and measures the mass-momentum vector as simply $m'c$. This particular mass m' measured by one relative to whom the mass is at rest is called the "rest mass." Solving the above equation for m in terms of m', we have

$$m=m'/\sqrt{1-v^2/c^2}.$$

This means that the mass is a function of the velocity, the greater the velocity the greater the mass as measured by him relative to whom the mass is moving. Similar generalizations are made for other three-vectors. The electric 3-vector current takes on a fourth or time-component ρc, where ρ is the charge density. The old 3-vector force of classical physics adds as time-component the activity or power, namely, the rate of doing work. On the contrary, the classical 3-vectors, electric and magnetic force, do not take on classical scalars to make 4-vectors; the two are combined into a single concept, a second order tensor

* To be strictly accurate, this is not a 4-vector. In the mass-momentum 4-vector, m is the mass density.

whose 16 components are reduced by skew symmetry to six independent components, for which reason the electromagnetic field is called a six-vector—although this terminology is poor.

The theory of relativity is, properly speaking, not simply a theory: it is a program for the generalization of classical science. The new forms are not to be deduced from the classical concepts, they are to be made over, reshaped. The new concepts are analogous, if you please, to the classical concepts, but this is quite a different matter than supposing them to be logically dependent upon classical forms. The new science is a separate structure, being erected not upon the foundations of classical science, but as an entirely new structure. Just as the causes and effects of those mythological animals of classical physics, were dragged from the land of imagination over the Pythagorean Bridge of Asses, so are the newer, more multi-headed myths to be brought into science over the Einsteinian Bridge, his newer metrical axiom.

But perhaps this is enough of the special relativity theory to convey what is relevant here. And besides, the theory has already been found to be inadequate. Whilst it works better than classical science, it offers no explanation of gravitation one whit more rational than Newton's.

And now comes Einstein again. Having pondered for a number of years after stating his special theory, it occurred to him that he had been, in effect, doing exactly as the classicists had done. In accepting his special relativity metric, he had fixed the frame of his picture, just as the Pythagorean metric had fixed the classical picture frame. Possibly phenomena refused to fit into this rigid frame because of its form. The special relativity frame was better than the Euclidean, but why take a fixed frame? This brings us to the next attempt to find a suitable picture frame.

In his general relativity theory, Einstein still clings to a homogeneous 4-geometry. But he assumes an elastic, not a fixed, frame. He takes for his new metrical axiom the most general conceivable quadratic form, $ds^2 = \sum g_{\alpha\beta}\, dx_\alpha\, dx_\beta$, where the 16 (10 independent) coefficients $g_{\alpha\beta}$ may be functions of the four coordinates, and where he does not say to begin with which one of the four coordinates is the time—leaving the question open, in fact, so that the time may be found to be a function of all four of the coordinates. Leaving the g functions undetermined, he took over Riemann's general propositions and let physical phe-

nomena themselves decide upon the form of the space-time frame. That is, he took phenomena as it appears from careful measurement and attempted to fit the picture frame to the picture. The analytical details of this picture frame construction are out of place here. Suffice it to say that Einstein did succeed in masterly fashion in geometrizing the gravitational phenomena.

Unfortunately, this is not yet the end of the matter. The present metric of relativity does not permit of the simultaneous geometrization of both mechanics and electromagnetism—which also exhibits "forces" acting through empty space. The theory which shall accomplish this miracle is already named the "Unified Field Theory" but it is not yet formulated. There have been several attempts, notably by Einstein, Weyl, and Eddington, to construct a unified field theory; but upon comparison of the facts of measurement with the predictions of these theories, none have stood the test.

The most valuable contribution of the relativity program appears then to be one of method. Instead of accepting a geometry fixed in form and seeking to force phenomena to fit it by the invention of divers fantastic "causes," we set ourselves the task now of seeking that frame for our picture which best fits upon nature, letting nature herself be judge of the excellence of the fit.

There is now coming over the horizon a new possibility which may have an important effect upon our notions of space and time. In Dirac's one of the various formulations of the quantum mechanics, a new type of concept appears called the spinor. The simplest spinor is a two-component entity, a sort of square root of a special relativity 4-vector. The components of a spinor do not fit nicely into our picture frame. We can not lay off one component along x, one along y, one along z, and one along t. Yet it is possible to show by the theory of groups that any special relativity equation between tensors may be translated into an equivalent equation between spinors. What does this do to all the imagery, the mythology, the causes and effects, behind our equations? Tensors have certain intuitive properties; they fit into the frame. But spinors are so queerly shaped—they even involve the hitherto little used imaginary numbers—that so far, only certain combinations of them can be made to fit the picture frame. It is an interesting speculation (I offer it as nothing more) that these new "causes" and "effects," namely, the

spinors, may later on produce rather violent changes in our notions of space and time, particularly if some mathematician succeeds in formulating some similar concept covariant to general relativity transformations.

Thus I say that Geometry, the first and noblest of sciences, has played in the past and will probably continue to play the dominant role in science. It certainly dictates the form and to some extent the content of all scientific concepts. It is the stage upon which those abstract actors, the causes and effects, play their scientific roles. It is the picture frame wherein that greatest of all artists, the creative scientist, paints his pictures.

So far the natural philosopher has painted in his space-time frame only the primeval 2-and-1 picture, the Euclidean 3-frame picture, the Galilean-Newtonian 3-and-1 picture, and the several Riemannian-Einsteinian 4-dimensional pictures. But there are possible many such frames, and but these few are without form and void, and darkness lies over their depths; but the creative spirit of man will move over the face of their waters and people them with his creations.

SHORTEST RADIO WAVES

The shortest continuous radio waves ever produced are being used in experiments at the University of Michigan. They are only 6.4 millimeters (about one-quarter inch) in wavelength, report Drs. C. E. Cleeton and N. H. Williams of the department of physics.

So tiny is the tube used to generate the waves that it is assembled under a magnifying glass and its outside dimension is less than one quarter of an inch, state the scientists in their report to the current *Physical Review*.

Radio radiation generated by the equipment is being used for studies of the molecular structure of gases including water vapor. The minute rays have many of the properties of light and travel in straight lines when focussed by a concave mirror. Pieces of black paper, hard rubber and wood are transparent to the rays.

The possibility of using them for communication purposes is remote since they are rapidly absorbed by the water vapor in the atmosphere. It is by a study of this absorption, in fact, that scientists are learning new facts about the molecular makeup of water vapor.

The 6.4-millimeters radio waves represent about the limit of radiation which can be produced from vacuum tube sources. To get shorter waves the dimensions of the radio tube must be decreased and ultimately becomes a mechanical impossibility.

For waves shorter than six millimeters it is necessary to use either the radiation from a quartz mercury arc lamp or spark sources in air. The wavelength region from one-tenth millimeter to six millimeters waves is about the last untapped "no man's land" of infra-red research, for only a few isolated measurements have as yet been made in this region.

THE PLACE OF PLANE GEOMETRY IN THE SECONDARY SCHOOL CURRICULUM

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For some time the value of mathematics as a secondary school subject has been seriously questioned, and in some instances the subject has been dropped as a requirement for graduation from the high school. Beginning with the second semester, February 1, 1937, mathematics in the high schools of the city of Chicago becomes an elective. As a result, teachers of mathematics are beginning to examine their subject critically for the purpose of eliminating non-essentials and replacing them with material that the pupils can comprehend and will find helpful in meeting the needs of everyday life. This inquiry has even been extended to the elementary school with the result that a Committee of Seven was appointed by The Northern Illinois Conference on Supervision for the purpose of carrying on co-operative research in arithmetic. In a recent article* by one of its members referring to the grade placement of the topics of arithmetic the following statement appears:

"If the child does not undertake to complete any of these topics until he has reached the mental age usual for the grade to which the topics are above assigned, and if he has a thorough grasp of the necessary foundations, his chances of successful achievement are very much greater than under the traditional curriculum."

This statement was made as the result of experimentation to determine at what mental age level each arithmetic topic could be successfully taught. An experiment carried on by the writer while in the University High School at the University of Chicago leads him to the belief that committees on mathematics could perhaps stem the tide of feeling against mathematics if similar studies were carried on at the secondary level in order to determine at what mental levels pupils are capable of successfully completing the various topics of secondary school mathematics. The experiment reported in this paper concerns itself with plane geometry but there is no reason why the other branches could not be similarly studied.

* Washburne, Carleton, "The Values, Limitations, and Applications of the Findings of the Committee of Seven," *Journal of Educational Research*, May, 1936.

When the mathematics program at the University High School was reorganized, plane geometry was taken out of its traditional place in the Sophomore year and moved up to the Junior year. The question that then arose was one concerning the effect of postponing plane geometry for one year. Would pupils in the Junior year, because of greater maturity, show greater success with the geometry? Obviously a comparison of the achievement of the group studying plane geometry in their junior year with that of a group studying the subject in the sophomore year would answer the question. From an administrative standpoint, it was not possible to set up two such groups for experimental purposes, hence it was decided to compare the achievement of the junior class with that of a similar group which had studied plane geometry during the previous year

BRESLICH GEOMETRY SURVEY TEST MEDIANS

Parts		I	II	III	IV	V	Total
Highest Pos. Score		20	8	11	43	21	103
Schools	1	13.4	5.0	3.4	15.0	2.8	40.4
	2	15.6	6.4	6.3	15.3	3.2	45.7
	3	15.1	7.1	4.3	15.8	4.4	47.5
	4	12.9	6.9	5.2	14.7	4.3	43.0
	5	12.7	4.0	3.8	13.3	2.6	34.0
	6	14.8	4.9	4.4	16.1	3.8	43.0
	7	6.3	4.6	5.8	18.3	1.2	39.4
	8	12.7	4.8	3.7	16.3	1.2	42.6
	9	15.2	6.1	5.4	14.7	2.9	40.2
	10	17.7	6.2	5.8	19.5	3.5	51.9
	11	14.6	6.6	6.1	18.4	6.0	51.5
	12	13.9	6.4	6.6	17.4	6.5	49.4
	13	14.8	6.6	6.3	17.6	6.4	52.3
	14	15.2	6.4	4.7	17.8	3.8	47.4
	15	16.6	6.5	5.4	16.7	4.3	51.4
	16	16.5	6.5	5.9	19.4	4.2	53.3
	17	13.8	6.7	4.2	24.3	5.0	55.0
	18	14.3	8.0	6.2	19.1	4.1	50.0
	19	13.0	4.2	5.2	15.3	4.5	42.0
	20	18.1	6.5	5.9	20.9	5.9	57.2
Group A	21	13.1	6.3	5.9	20.7	3.4	50.0
	22	14.4	4.7	4.2	16.6	2.5	42.5
	23	13.8	6.7	2.6	14.9	5.1	42.9
	24	14.7	4.7	4.3	20.2	2.7	48.8
	25	12.5	6.1	2.4	11.6	2.7	31.5
All Schools		15.2	6.3	5.2	18.2	4.3	49.1
Group B		16.8	7.9	7.6	28.3	9.6	71.0
I.Q. Group A	113.4						
I.Q. Group B	109						

which was their sophomore year. Fortunately, this could be done because the Breslich Geometry Survey Test is administered to the pupils each year and the test results are kept on file. Thus, at the end of the first semester, the Juniors were given the same test that had been administered to a previous sophomore group. In this study the sophomores will be designated as group A and the juniors as group B.

At the time that group A took the test, it was also administered to a number of schools within the vicinity of Chicago by the Judd Club. The results revealed that the geometry situation at the University High School was no different than that in the other schools. The median score obtained by group A was slightly higher than the median for the entire group of schools. The results together with the scores obtained by group B are shown in the above table. The I.Q.'s for groups A and B are also given.

Part I of the test deals with geometric concepts and is divided into two sections. Section A, containing eleven items, involves definitions, while section B, with nine items, involves the classification of angles and polygons. The object of this part of the test is to determine the pupil's knowledge of the vocabulary of geometry. In this material, the median for group B is 3.7 greater than the median of group A and 1.6 greater than that of the group of schools as a whole. This gain was not expected since the materials in this section are used in daily expression and thinking. This frequent use makes for mastery, and hence but little difference in the results for the two groups was expected. It was not felt that maturity would enter into the results as a factor because no reasoning was involved.

Part II continues the measurement of a knowledge of terminology. It consists of four constructions that have been performed for the pupil. The pupil is expected to recognize what has been done and to use the proper terminology in naming the construction. Here again it is interesting to note that the more mature group made a gain of 1.6 over group A and over the median for all schools. In justice to group A it can be said that the median score of 6.3 on part II and 13.1 on part I represent a satisfactory achievement since the scores would probably have been higher had the terms "locus" and "central angle" been omitted from the test. These terms were not familiar to them, since they had just started the unit dealing with loci and the term "central angle" appeared in a still later unit. The

majority of the pupils in the more mature group working at a greater speed came into contact with the terms in question and were able to identify them. Pupils in the sophomore group who did identify the terms stated that they remembered them as part of the intuitive geometry that had been studied. On the whole, it can be stated that the difficulty in acquiring the vocabulary or terminology of plane geometry is but slight as compared to the difficulty experienced in other phases of the subject.

Part III deals with relationships and comprises two sections. Section A contains 8 items dealing with relationships of angles, while section B consists of 3 items requiring the ability to translate verbal statements into symbolic form. On this part of the test the achievement of group B exceeds that of group A by 1.7 points, and the norm for all schools by 2.4 points. This part of the test is much more difficult than the preceding sections, and a gain of 2.4 points is significant. It is interesting to note that in this part of the test, where some reasoning is required, the gain over the norm for all schools exceeds the gains in the two previous tests.

Part IV is really designed to measure reasoning ability. It is concerned with demonstrative geometry, and is a measure of one of the most important outcomes as a result of the teaching of plane geometry, namely, the ability to draw conclusions. It is divided into three parts, section A, using axioms in reasoning problems, section B, selecting axioms in reasoning problems, and section C, arranging facts in logical order. In this part of the test, one would expect maturity to play an important part in achieving success. The results obtained on this part of the test confirm this expectation very forcibly. The median for group B exceeds the norm for all schools by 10.1 and the median of group A by 7.6. These gains are exceedingly large and can be attributed to but one factor, maturity, since subject matter and method of teaching did not vary in any way. Certainly the gain can not be charged to superior mentality for group B, since the average I.Q. for this group is 4.4 below that of group A.

The situation in part V is similar. Here the pupil is tested on the application of geometric principles. Five practical situations are presented, and the pupil is asked to give the geometric principles involved in each. Here again tremendous differences in achievement are noted. The median for group B is more than twice that of all schools, and almost three times as great as the

median for group A. Again maturity proves to be an important factor in achievement in plane geometry.

For the entire test the median score of group B is 21 points greater than that of group A. This represents a gain in achievement of 42%. The excess over the norm for all schools is 21.9 points or 44.6%. And this is not all by any means. Group B finished the course before the allotted time, and was able to complete a unit in Trigonometry and use a whole month for a review of difficult parts of algebra. Certainly the results present definite evidence that plane geometry should have a place somewhere beyond the second year. Perhaps the senior year is the place for it. The writer believes that in the senior year the solid geometry could be completed, in addition to the plane geometry, with greater understanding and facility. Likewise the algebra could be postponed, and the equivalent of one and one-half years of algebra could be completed in the Junior year. Or perhaps experimentation would result in reversing the above, putting the geometry in the Junior year, and the algebra in the Senior year.

Those in charge of mathematics should take cognizance of these facts, or else we may find algebra and geometry being moved up into the college, where they were previously taught. They should remember that algebra and geometry were originally intended as studies for adults; they were organized to meet the needs and abilities of all the people, and in no sense of the pupils who are studying them today.

THE BLOCK AND TACKLE EXPERIMENT AGAIN

By F. W. Beckwith
Monessen, Pennsylvania

I read with considerable interest and profit the article by Mr. Perry in your October issue concerning evidences of thinking ability on the part of high school physics pupils. However Mr. Perry cites the weight of balance A as a correction factor when using the balance in an inverted position. If "one student in ten" is a good enough reasoner to think that the weight of the balance is involved, surely there must be one once in a while who is keen enough to see that the weight of the balance affects the reading not one whit. The only correction is due to the hook and drawbar which is taken care of by adding the force required to bring the pointer up to zero when inverted and which, I believe, is taken care of by implication in Mr. Perry's other correction.

NATURE RECREATION IN LOUISVILLE

By William Gould Vinal
National Recreation Association

Every community stands out as individualistic in some phase of nature recreation. Cleveland has its great metropolitan park system with trailside museums, nature trails, and park naturalists. Minneapolis has its urban spaces with beautiful Chalets traceable to the Swiss mind of Jacob Wirth. St. Paul is a city that typifies the chain of cause and effect since lumber days. Milwaukee with its German nature culture is stressing conservation. Pittsburgh children are guaranteed fine nature influence through the combined efforts of the public school system, the Carnegie Museum, and the park leaders. This does not mean that other cities do not have their parks, conservation, school nature study and nature heritage, for they all do.

Louisville, the "City of Louis," is a place rich in nature heritage. It has beautiful mansions, gardens inherited from old Virginia, immaculate yards, groomed doorsteps, and southern hospitality just as fine and wholesome as in the days of Audubon or Muir. Everyone takes pride in the well-wooded parks. Hosts will show you the fine collection of trees and shrubs in Cave Hill Cemetery. The "three sisters" and "big brother" Sycamores in Cherokee Park have been well cared for by the tree surgeons. All of these are pointed out by every inhabitant. Furthermore, Louisvillians know about such impossible things as the cow jumping over the moon but ask them about the location of the tree where "D. Boone shot a bar," or the prehistoric coral reef, or, who was John James Audubon and only one out of twenty will know. Nature illiteracy is common in every city and yet with a brief period of library-mining one may always find local nature lore. By knowing the nature education of the past, one obtains nature patriotism and nature patriotism is something that no progressive community can afford to overlook. It is part and parcel of its well being.

Let us hark back to the days of buffalo roads when a network of pathways led through the forests to and from salt licks. Forty "Long Hunters" came along these buffalo trails from Virginia under Colonel James Knox on a two year's hunting expedition. They went back with stories of the beauty and fertility of Kentucky and dwelt upon the abundance of wild game. They did not suspect that by 1819 not a buffalo or beaver would be left.

Neither could they surmise the part that the English names of Virginia would play in this new land. And there was no hint that the word "colonel" would rise to fame and the word "scout" all but disappear for the scouts showed as much bravery and fortitude as the colonels.

The Wilderness Road, the route of the "Long Hunters," was first marked by Daniel Boone (March 1775) by blazing trees. Sometimes spoken of as Boone's Trace, it extended from Cumberland Gap to the Falls of the Ohio. It was as early as September 1773 that Boone with his own family and five others set out to settle Kentucky. They were soon joined by other settlers.

In 1778, General George Rogers Clark founded a settlement at the Falls of the Ohio. For safety from the Indians the settlers lived on an island in the river and raised corn, hence the name Corn Island. On Christmas Day they came to the mainland to celebrate. A puncheon table at the fort at the foot of the present 12th street was set with bounties of the forest. When the shadow on the sundial indicated twelve the feast began. It consisted of venison, buffalo, bear, wild turkey, opossum, hominy, cornbread, ash-cake and pumpkin pie. Clark showed great vision but even he could not prophesy that within his day the wild animals would disappear and that when the fine forest on Corn Island was effaced the river would cut away the island until nothing but a pile of rocks and mud would be left. Nor could he predict 1936 dust storms traveling eastward into the Atlantic. If there could have been seers and nature prophets down through the generations this story would be considerably different but such is the penalty that we have to pay for nearsightedness. Will it always be necessary for history to repeat itself?

The early settlers, like Boone, had an inherent love of nature, and were familiar with the forest. Buckskin breeches, the raccoon cap, deerskin moccasins, linen shirts, linen sunbonnets, woolen stockings, and cotton handkerchiefs were products of the environment. The boys learned early to trap turkeys, to tree coons, to shoot a rifle, to make a hickory broom, to make soap, candles, and maple sugar, to fashion utensils of wood, and to grind corn for bread. The river abounded with fish and every youngster was proficient with the line and hook. Such a lad was Christopher Columbus Graham (b. 1784). He carried a gun to school in his three mile walk through the forest. Graham was the first graduate of medicine west of the Alle-

ghenies but never forgot his early interests. He contributed to the Public Library his collection of minerals, fossils, and specimens of all kinds.

Josiah Espy (1805) described the fossils at the Falls of the Ohio as "all kinds of roots, flowers, shells, bones, buffalo horns, buffalo dung, yellow-jacket's nests, etc." It was easy then, as now, for the imagination to create a "petrified wasp's nest" out of a colonial coral or a buffalo horn out of a slightly coiled cephalopod. Only recently I heard of a teacher who described a piece of slag from a blast furnace as a fossil wasp nest and I am continually being told about a fossil human foot or petrified buffalo horn.

Constantine Samuel Raffinesque (1784–1840) was a visitor at Ohio Falls where he observed the ancient coral reef of the Devonian Sea. He is said to have located 505 ancient remains of the mound builders. Dr. David Starr Jordan described him as "the first student of our western fishes," and "the very first teacher of natural history in the west." During his nomadic career he visited Audubon at Henderson, Kentucky.

Dr. Gerard Troost (1775), a Holland geologist, came to America in 1810. After leaving the school at New Harmony he became the first state geologist of Tennessee. His mineral collection (1,200 on display and 3,000 other specimens in drawers) is to be found in the basement museum of the Louisville Free Public Library. Some of the collection was said to have been stolen by soldiers during the Civil War.

John James Audubon (1785–1861) lived in Kentucky for twelve years. He not only passed a night with Daniel Boone in a West Virginia log cabin but described Raffinesque as a character who must have resembled Robinson Crusoe. He goes on to say that Raffinesque's "words impressed an assurance of rigid truth; and, as he directed the conversation to the natural sciences, I listened to him with great delight." The newly married Audubon (1808) at the age of 28, came to Louisville to make it his home. He traveled from Philadelphia to Pittsburgh by a Conestoga wagon and then took a two day voyage down the Ohio in a flat boat. He said that Kentucky was a "sort of promised land for all sorts of wandering adventurers." As a business man he was like a square stick in a round hole. One is reminded of the teacher who called Edison a dunce. Audubon, the boy, had been found sketching a bird instead of plowing, and was called lazy. Audubon, the store man, turned

a deaf ear to business and listened to the "Call of the Wild." The thrifty English relatives of his wife believed him a failure. With his family in need of food and clothing his wife still appreciated his genius and fostered his passion for nature and birds. He wrote in 1835: "We had marked Louisville as a spot designed by nature to be a place of great importance." It was his "beloved country." "Among all these adverse circumstances . . . I never for a day gave up listening to the songs of our birds . . . This never failed to bring me the most valuable of thoughts and always comfort."

Audubon had an invincible will to accomplish that which he believed to be right. When rats destroyed several hundred of his sketches he went to work again to finish what he had set out to do. His greatest work, "Birds of America" (1827) was done in Kentucky. It took fifteen years to complete the manuscript after he first showed it to a London engraver. Picture the eminent success of a man who did not mind poverty, who was thought lazy and queer, who had no reference library on birds, and who was frequently interrupted by his "infernal mill." His book contains 1,065 colored birds. Recently one volume sold for $6,500. One of his elephant books is locked in a special wooden frame in the basement museum of the Louisville Free Public Library.

It is interesting to note that the Parrokeet, now extinct or at least last seen in 1906 in the Everglades of Florida appears in "Birds of America" as a Kentucky bird. One specimen, as well as a pair of passenger pigeons exist in the Louisville Museum. This bird was also described by the Scotchman, Alexander Wilson, who visited Audubon in March 1810. They became well acquainted and hunted together although Wilson was not very gracious in later references to his congenial host. Audubon also became the father of bird banding when he placed silver threads on pewees about 100 years before the organization of Bird Banding Societies in the United States. The Hattie Audubon Bird Club of Louisville is named from his granddaughter and only near kin.

The "Delineations of American Scenery and Character," by J. J. Audubon (G. A. Baker and Co., 1926) has an Introduction by Dr. Francis Hobart Herrick, Professor Emeritus, Western Reserve University and author of the standard biography of the great ornithologist. The publication which has sixty sketches of events between 1808–1834 throws considerable side light on

pioneer life in Kentucky during that quarter of the century. Besides such essays as, A Barbecue near Louisville, and the Stunning of Squirrels in Kentucky by Daniel Boone, it has a Moose Hunt in Maine, and Eggers of Labrador.

The prophetic words of Audubon when he came back to Louisville after about twenty years have just as great a significance today. "When . . . I recall the grandeur and beauty of the almost uninhabited shores . . . when I know how dearly purchased . . . by the blood of many worthy Virginians . . . the vast herds of elk, deer, and buffaloes have ceased to exist . . . the din of hammers and machinery is constantly heard . . . I pause, wonder, . . . can scarcely believe in its reality . . . Our Irvings and our Coopers . . . I hope . . . will render the picture, as it ought to be, immortal." Is it not equally true today—that Louisville needs a bard or poet to write the praises of its nature heritage?

Audubon connected the old with the new. He knew the English pioneers, the negro slaves, the French immigrants who reproduced the flower gardens of their native home, and saw the beginning of the machine age which was to lead to the Irish contribution of the Cabbage Patch. He knew Raffinesque of New Harmony. There is no evidence that he knew others of the New Harmony school who were to leave their impress on the nature movement at Louisville. We have already mentioned Troost and we should add David Dale Owen who was state geologist in Kentucky from 1854 to 1857 and Major Sidney Lyon who superintended the topographical survey of Kentucky. In mentioning the nationality gifts to Louisville's nature culture we should not omit the German immigrants (1840–50) who became the principal market gardeners.

In considering the more recent nature heritage of Louisville that has arisen within the memory of the oldest inhabitants we wish to start with Stephen Collins Foster who composed and wrote his immortal lyric "My Old Kentucky Home" in 1852. There are those who will be surprised to find the writer of American folk songs described in this treatise on nature recreation but it was surely the view of nature about the Old Kentucky home that inspired the song. Now as in 1852, one making a pilgrimage to this shrine goes east on the Louisville turnpike from Bardstown and crosses the beautiful Beech Fork River to mount the table land beyond. The old brick manor house was built in 1795 by Judge John Rowan. This 235 acre plantation

with its slave cabins and mansion have been restored to the conditions that existed when Stephen C. Foster was visiting his relatives in this old home. Tradition has it that Foster was sitting under a tree where he could see the "Corn-tops ripe and the meadows in the bloom." The home is still screened by gnarled ailanthus trees of great size (one wishes that they were Kentucky Coffee Trees). The antique secretaire stands in the high feudal hallway where he made his "fair-copy." Glancing into the rooms one sees a home with its colonial mahogany and rosewood and immense fireplaces. Whoever visits the Old Kentucky Home State Park will hear the song with deeper meaning and will surely have memories of grand buildings, stately trees, and blue grass pastures.

The next nature recreation event of significance to Louisville was the "Thousand-Mile-Walk to the Gulf" described by John Muir in a book of that title and published by Houghton Mifflin (1916). Muir started on his trek Monday, September 2, 1867, and covered about twenty-five miles a day. Two days before the journey he wrote in a letter about the powerful impulse which caused him to be "Doomed to be carried of the spirit into the wilderness." He had a similar nature passion as Audubon which caused him to say: "I wish I could be more moderate in my desires, but I can not, and so there is no rest." Curiously enough Muir steered through Louisville with a compass without speaking a word to anyone and "strode away among the Old Kentucky Oaks." He crossed Kentucky, Tennessee, Georgia, and Florida fully expecting to continue through the tropical jungles of the Andes and down the Amazon.

Muir called Kentucky "the greenest, leafiest state I have yet seen." Perhaps he said this as he had previously botanized in the coniferous forests of Canada, Michigan and Wisconsin and on the wide prairies of Illinois. He, like Audubon, kept copious notes. He "entered a sandy stretch of black oak called 'Barrens'," and then "came to a region of rolling hills called Kentucky Knobs." Iroquois Park is on one of these knobs to the south of the city. His interest in natural art was evidenced in speaking of Mammoth Cave, "Fortunately the cave has been unimproved."

The undercurrent of Puritanical objection to enjoying the outdoors that faced Audubon a half century ago still existed. One night Muir "put up" at the home of a blacksmith who upbraided him as follows: "You look like a strong-minded man,

and surely you are able to do something better than wander over the country and look at weeds and blossoms. These are hard times and real work is required of every man that is able. Picking up blossoms doesn't seem to be a man's work at all in any kind of times." Muir had an ingenious but forceful reply for the occasion. "Now, whose advice am I to take, yours or Christ's? Christ says, 'Consider the lilies.' You say, 'Don't consider them'." The blacksmith acknowledged that he had never thought of blossoms in that way before. It was to be another half century before a National Recreation Institute would come to Louisville, in which there was to be taught Nature Recreation to leaders. Such is the march of time.

Nathaniel Southgate Shaler (1841–1906) was Kentucky born and bred. Although Newport, Kentucky, was his home his being state geologist (1874–80) often brought him to Louisville. He was a delicate child, had no early playmates, and overheard the slaves saying that he would not live beyond childhood. When his health finally allowed him to attend school he was regarded as a dunce. Like Edison, he was a non-conformist. In his autobiography (Houghton Mifflin 1909) he tells us that at ten he was interested in insects and then birds. He raised pigeons, hens, geese, and ducks. "I count that noble game-cock and that glorious elephant as among my teachers: they brought me to love animals and appreciate man's relation to them." "I was by instinct a mouser after things in the earth." His father had some knowledge of minerals. All this he calls "desultory education." And so it was. Too often it can be written that great naturalists became great in spite of their first teachers. Today, early interests and abilities are compass and chart for the progressive guide.

Shaler's early experience bore fruit. His classical book "Domesticated Animals," illustrated by Ernest Thompson Seton, is a typical example. Referring to his college days at Harvard he writes, "I was more naturalist than humanist . . . the life of the fields, the brooks and rocks, was nearer to me than that of the men and thoughts of long ago . . . Agassiz had the most influence on my life of any of the teachers to whom I am indebted." The writer remembers Dean Shaler on three different occasions. When a student at Harvard, my roommate stayed out of class one day because of a cold. To our astonishment, that evening we had a call in Old College House from the Dean of the Laurence Scientific School. I was equally astonished

when I next saw Dean Shaler (he was 63 or 64 years old at the time) in shorts on the running track of the gymnasium. The fact that he had whiskers put him in the same class as my grandfather who was also a Civil War veteran, and to picture my grandfather in running pants going around the Harvard Gym was too absurd to even contemplate. All of which reminds me of a field trip that was led by Professor Shaler. One of the boys said, "Here comes the old man now," to which a more experienced student replied, "Shut up, if he hears that he'll walk hell out of us." My inner feelings were again deeply stirred at his funeral in my senior year (1906) when his remains were carried to Appleton Chapel between continuous lines of sorrowing undergraduates. I regret that I did not know him better. I now know that it is the man and not the subject although in this instance both would have been most acceptable.

If the story of the naturalists of Louisville teaches anything it shows that one may be interested in nature from many angles. There is Boone, the scout; Audubon, the artist; Foster, the musician; Muir, the tramper; and Shaler, the teacher. Now we come to Ellen Churchhill Semple (1863–1932), the geographer. Both her family and her Kentucky heritage laid a foundation for greatness in her special interest. Graduating from Vassar (1882) at 19, she studied at Leipzig in 1891–92 and 1895. She was shrewd enough to see the possibilities of geographical environment as a factor in human development. While writing that far-reaching book, "American History and Its Geographic Influences" (1903), Ellen Semple spent summers in the Catskills living alone in a tent. Outdoor life with invigorating air, with now and then time off to feed the chipmunks, would appear to be ideal for writing.

She is said to have tramped 175 miles to study Japanese agriculture at different elevations and she followed the route of the invading army of Xerxes (480 B.C.) to Athens with equal enthusiasm. Miss Semple was professor at the Universities of Chicago and Kentucky and during her latter days taught at Clark University (1921–1932).

Of the long list of native naturalists perhaps Alice Hegan Rice is most typically Louisvillean. Louisville has always been her home. Here, again, is a different slant on the philosophy of life and my fellow naturalist may again rise up against such an all-inclusive list. Alice Hegan Rice, like Gene Stratton Porter, writes human novels which deal with real people who are

nature's children. "Mrs. Wiggs of the Cabbage Patch" (1901) has the homely appeal of the cabbage patch without paint or talcum. Perhaps some of the readers are as ignorant as I am and do not realize that the "Cabbage Patch" was a shabby quarter of Louisville "on the other side of the railroad." This "Cabbage Patch" has disappeared except for a modest social center of the neighborhood by that name.

Alice Hegan had parents who appreciated the outdoors. Often times she retreated to their log cabin in the country. Although her negro nurse told folk tales of animals after the manner of Uncle Remus, Alice Hegan never wrote "Just-so-Stories" but drew her characters from the soil with "that touch of nature that makes the whole world kin." Mrs. Wiggs philosophy

"In the mud and scum of things
something always, always sings:

without footlights, trumpet, or acting calls for qualities of kindliness, friendliness, simplicity, homeliness, and humor. The record breaking sale of the book shows the nature-hunger of people for life that has simplicity and sincerity. This is the path to an American literature—a spot where folks are in a natural environment with a fund of plain common-sense. It is a revolt from a machine made world to the realities of life. Alice Hegan married the poet Cole Young Rice (December 18, 1902) and together typify the milk of human kindness. It has been their individual ways, as Mrs. Wiggs, which endorse the simple philosophy that says:

"I believe in getting as much good outen life as you kin."

Through all this lineage of illustrious naturalists who had a passion for worthy causes it is curious that no one arose to champion the parks. Someone has said that "Providence always causes the large rivers to flow by the large cities." "La Belle Rivere" was the name of the French explorers. When Louisville was laid out as a town at the Falls of the Ohio in 1779 the virgin forest stood in the way of sowing and reaping. General George Rogers Clark made a map (1779) and marked the area between 1st and 12th Streets, and between Main Street and the River as "Public." The story is that he planned to have several stretches of public property. Unfortunately, those areas were sold at auction to pay debts.

It was a hundred years before an old graveyard on Jefferson (1880) was converted into the first park of Louisville. In 1887, Andrew Cowan, who had explored the surroundings of Louis-

ville for a park system, presented a plan to the Salmagundi Club. Cherokee, Shawnee, Iroquois, and all four suburban parks appropriately named after the original naturalists of the region. Boone, Kenton, and Logan are fitting names for the inner parks.

In 1891, Frederick Law Olmsted became identified with park planning in Louisville. He said that "superb umbrageous trees standing singly and in open groups, distributed upon a graceful, undulating green sward, are to be seen there in higher perfection, than has yet been found in any public park in America." His counsel to the Park Commissioners (Commission formed in 1890) is equally good counsel in 1936.

"Develop . . . treasures of rural and sylvan scenery . . . regard for existing topographical peculiarities of the particular site. Second, recreation must not be discordant with natural character of that site; strenuously disappoint all notions . . . to spend public money upon objects of curiosity." To the credit of the Park Commissioners, although they have at times mismanaged funds, the outlying parks remain in a natural state.

Today, the best posted man in Louisville on things naturewise, is James Speed, the omnivorous nature writer for the *Post-Herald*. He grew up in Kentucky and for thirteen years was a Kentucky farmer. As editor of the publications of the agriculture department of the University of Kentucky and later editor of the *Southern Agriculturist*, he gathered a fund of experience which made him a popular lecturer in Chautauqua courses for eight years. Today he appears before young folks and luncheon clubs where he always wins his audience with his homely common sense and humor. His supplementary school nature readers, "Billy and Jane, Explorers," published by D. C. Heath (1922) are known outside his native state. James Speed is a profound student of outdoor life and his popular writings in the *Post-Herald* are potent factors in clarifying the nature lore situation.

There is no need to compare John James Audubon with Stephen Collins Foster or Alice Hegan Rice with Ellen Churchhill Semple. One genius differs from another genius. The Kentucky Cardinal is beautiful but so is the Jay Bird and the Mountain Laurel and the thorough-bred horse. Some naturalists find expression in music, some in poetry, and some with the brush. In Louisville it is easy to go on talking about the power of genius in nature lore. In every case it has been the lore of

simplicity which has made it possible to surpass. The longer one studies the nature study gifts of Louisville the more this idea grows upon him. Loyalty to home, to Louisville, to Kentucky is a genuine realism. Someone in analyzing leadership arrived at the conclusion that five per cent are creative leaders, five per cent are imitators, and ninety per cent followers. If this is true, Louisville has done nobly with her nature leaders. What is needed is to make the other ninety per cent sympathetic and intelligent followers. Create a flame of devotion to nature in the home, nature through music, nature through literature, nature through poetry, nature through art, and nature through country. The nature gifts of Louisville are greater than Louisville, they are American. Citizens of Louisville, awake to your nature heritages.

MAKING AN EXERCISE IN HIGH SCHOOL GEOGRAPHY SERVE THREE PURPOSES

By Margaret Riggs
Northwestern State Teachers College
Alva, Oklahoma

The high school teacher of geography is confronted repeatedly with the necessity for developing an exercise which will have in it the qualities of both physical and commercial geography. The well-rounded exercise will also make use of both factual and relationship ideas pertinent to the phase of geography being studied, and will at the same time seize upon any opportunity to increase a student's skill in the use of tools, such as graphs, maps, atlases, and even rulers. The following discussion sets up an exercise on climate, in the development and presentation of which an attempt is made to combine these features.

Before an instructor works out and presents a unit to a class, it is always necessary for her to give careful consideration to the interests, abilities, and geographical training of the pupils with whom she works. The inferences concerning students and subject matter which result from such considerations give a teacher the basis for the development of the unit. Evaluations such as these often result: (1) Most high school geography students will not familiarize themselves with the location of places and the use of maps unless the solving of a problem makes it necessary; (2) Most high school students, if *required* to do so, are

capable of accurately following directions which are clearly given, and of drawing and interpreting a simple graph; (3) Many high school students, when they first glance at directions, confound themselves with the apparent impossibility of carrying them out and consequently give up immediately; but if given time and encouragement they are capable of ferreting out each step and thus arriving at the completion of the task; (4) High school geography students should understand not only the types and effects of climate in particular areas, but should gain, also, a mental and graphic picture of the general climatic pattern of the world as a whole.

In this instance, where a summary unit on weather and climate is being organized, the preceding evaluations are of particular value. From them the teacher is able to draw and set up three specific purposes for the exercise, all of which point to general objectives for a good unit of study in high school geography. These three purposes are:

1. To aid in developing the ability to follow directions carefully and to present graphical material neatly and clearly.
2. To give students incidental but purposeful practice in the use of atlases, maps, and lines of latitude in locating places.
3. To help students to see and interpret, to some extent, the gradual change in seasons from pole to pole and thus to summarize the general climatic pattern of the world.

The time used for the completion of the exercise need not exceed two class periods and two or three hours outside of the classroom. When the directions are first handed out to the class, each pupil may be given fifteen minutes in which to read and reread the work carefully in order to familiarize himself with it. No student should be given any supervision or aid until he has made an honest and determined attempt to understand what is required. The following is an example of the mimeographed instruction sheet which is handed to each student:

Purpose:

To construct a graph which will show the general change in climates from pole to pole. The type of climate at any given place is suggested by the length of the growing season at this place, that is, the number of months free from frost.

Instructions for drawing:

1. Sketch the graph off in pencil first and present to the teacher for approval before making the final copy.

2. Final copy must be in ink.
3. Use regulation typewriting paper 8½ by 11 inches.
4. Use this heading for the graph: NUMBER OF MONTHS OF GROWING SEASON AT TWENTY-THREE SELECTED PLACES IN THE WORLD.

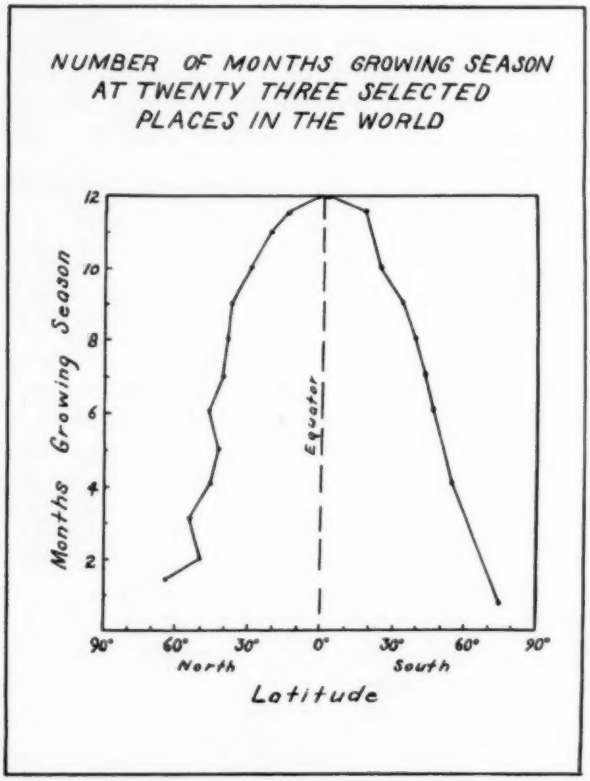
Construction of the graph:

1. Find the approximate latitude of each place in the accompanying table and record it in the column headed "Latitude." Be sure to indicate whether it is north or south latitude. Use for references: maps, charts, atlases, or any other sources which give latitudes of places.

Place	Months Growing Season	Latitude
Guayaquil, Ecuador	12	
Para, Brazil	12	
Singapore, Straits Settlements	12	
Manila, Philippine Islands	11½	
Burketown, Australia	11½	
Calcutta, India	11	
Longreach, Australia	10	
Jacksonville, Florida	10	
Rosario, Argentina	9	
Sacramento, California	9	
Bahia Blanca, Argentina	8	
Valencia, Spain	8	
Rawson, Argentina	7	
Rome, Italy	7	
Dunedin, New Zealand	6	
Seattle, Washington	6	
Bucharest, Roumania	5	
St. Johns, Newfoundland	4	
Magallanes, Chile	4	
Moscow, U.S.S.R.	3	
Semipalatinsk, U.S.S.R.	2	
Dawson, Yukon, Canada	Less than 2	
South Victoria Land, Antarc.	Less than 1	

2. Now that you have the latitudinal location of each place the names of the cities themselves will be used no longer. Only their latitudes and the growing season for these places are now necessary.
3. Draw a perpendicular line (6 inches long and 2 inches from the bottom of the paper) one inch from the left side of the paper. Label the line MONTHS GROWING SEASON. On this line mark off 12 places for the months of the year and number from 1 to 12.
4. At right angles to the perpendicular line and 2 inches from the bottom of the paper draw a horizontal line 6¾ inches

long. Label the line LATITUDE. On this line mark off 18 places ($\frac{3}{8}$ inches each). Each place will represent 10° of latitude. Let the 9th mark be labeled 0°; then each mark to the right of this will be a 10 degree interval of south latitude (to 90°) and each mark to the left will be a 10 degree interval of north latitude.



Example of graph resulting from exercise

5. By using the number of months growing season and the latitude (refer to table) for each city, you can now place a dot on the graph which will indicate its position in the climate of the world. (Example: If the latitude of Valencia, Spain is 39½°N, then find 39½°N on the LATITUDE scale. Draw a line perpendicular from this until it meets a horizontal line drawn from the 9th mark on the MONTHS GROWING SEASON scale. The place at which these two

lines meet will be the location of the dot representing Valencia.)

6. When all 23 points are located, connect the dots with a heavy red line, from the greatest number of degrees north latitude to the greatest number of degrees south latitude.
7. Name, and with a broken line indicate, the position of the equator.

The accompanying drawing is an example of the kind of graph which should result from carrying out these directions. When the graphs are completed, a part of a class period may be given over to having the students interpret them. To the teacher's question, "What are some of the things which the graph shows you as to the differences or similarities in climate thruout the world?", such answers as these will no doubt be given:[1]

1. The graph shows that the farther places are from the equator, the shorter the growing seasons are.
2. It shows that, in general, the climate changes in the same way proceeding south from the equator as it does in going north from the equator.
3. If the growing season or frost-free period is 12 months long at the equator, it is evidently warm there the year round. If it is less than 2 months long near the poles, the climate there must be cold most of the year.
4. If the latitude of a place is known it might be possible to determine what types of crops would be grown there or what the habits of the people would be.
5. If a person went from near the north pole to near the south pole, he would gradually get warm and hot, and then he would grow cool and cold again.
6. In general, places of low latitude have long growing seasons while places of high latitude have short growing seasons.
7. Places that are at the same degree of latitude, whether north or south of the equator, have approximately the same length of growing season.
8. The closer places are to the sun (represented by the equator) the longer the growing seasons are.

While some of these interpretations may seem more advanced than others, all have value if they represent real thinking on the part of the student. The worth of the exercise as a whole depends

[1] These are actual answers made by students in a class in High School Geography, College Demonstration School Cape Girardeau, Missouri.

on the interest the students take in the preliminary map work, the neatness and accuracy of their graphs, and the thoughtfulness of their final interpretations. In accordance with these results the teacher may feel satisfied as to whether or not the three purposes for which the unit was planned have been accomplished. It should be remembered that the purpose of the exercise is largely destroyed unless the student does all that he possibly can for himself.

FUSION IN PRACTICAL PHYSICAL SCIENCE—AN EXPERIMENTAL COURSE

By Robert B. Todd, Jr.
Oakland Technical High School, Oakland, California

Because of the need for providing adequate, practical experiences in the fields of the physical sciences for pupils who do not desire or are unable to take chemistry or physics, it was decided to build a year course that fused the subject content in the physical sciences and furnished the pupil with practical experiences. A practical and useful science course such as this has been constructed at Oakland Technical High School and has been given during the school year 1935–36, thus the statements relative to purpose, content, method and value which follow should be considered only as indications and not as results.

Among the major purposes of the course are the following:

First, to adapt instruction to the needs, interests and abilities of eleventh and twelfth grade pupils who, as was previously stated, desire some science but do not wish, or are unable to take chemistry or physics.

Second, to discover the most effective teaching method for presenting science material to a non-college group.

Third, to ascertain a knowledge of the needs, interests and abilities of eleventh and twelfth grade pupils and use this knowledge in arranging the content of the course.

Fourth, to produce an independent type of investigation, experimentation and study by the pupil.

Fifth, to provide opportunity for the pupil to explain, use and apply the scientific method in daily life.

The course consists of twelve natural and vital units of experience, each centering about a real problem, irrespective of

the subject matter, and each, it is hoped, leads to a greater capacity for efficient living. Applied Science is in a stage of transition. Originally there were topics in content, but these have given way to experiences revolving around fundamental principles and themes. These are being replaced by a continuous stream of experiences arising from the interests and responses of the pupil. The pupils' own experiences are used in a concrete way. From this there can be no logical or traditional organization of outside materials, but unity and integration are furnished from pupil activities and responses.

The activities and units are summarized in Table I.

TABLE I. UNIT OUTLINE OF APPLIED SCIENCE

Units—First Term Activities	Units—Second Term Activities
1. Measuring and Buying	7. Heating for Our Health
2. Using Water. Power-Solvent	8. Working With Machines
3. Controlling and Using Air	9. Lighting Our Homes and The Sky
4. Enjoying Rocks and Soils	10. Electrifying Our Surroundings
5. Analysing Matter and Motion	11. Communicating with Others
6. Consuming in the Home	12. Traveling on Land, Air, Water

It should not be assumed, however, that these topics are of primary importance. They are merely frames on which to form the pattern of the pupils' needs, interests and abilities. Each unit is based on two considerations. First it is dependent upon adaptions of fundamental scientific principles as advanced by the *Thirty-first Yearbook* of the National Society for the Study of Education.[1] These principles were modified, the pertinent ones selected and the units partially based on these. The second consideration consists of the answers to the following questions. Is the experience significant to an understanding of contemporary life and the organized field of knowledge? Has the experience any value for child interest or adult use?

There are two phases to the procedure of applied science, that of the pupil and that of the teacher. Short previews are given with many demonstrations to arouse the interest of the pupil and to direct his activities into desirable channels. Once convinced of the need and value of the unit, experiments are devised to further elaborate the fundamental principles and questions that arise in the pupils' minds. An outline of the desired

[1] Powers, S. R., "The Objectives of Science Teaching in Relation to the Aim of Education." *Thirty first Yearbook*, National Society for the Study of Education, Part I. Public School Publishing Co. Pages 53–55, 1932.

content and activities is posted on one of the bulletin boards, a few of the experiments are performed by all. This outline includes only those experiments basic to an understanding of their experiences. These are briefly written up, then the pupil answers several oral questions to determine whether or not an adequate understanding of the problem has been attained. The few basic experiments being done, the pupil becomes interested in many other phases of his recent experience, so he next turns to them. During several weeks on a unit, all the pupils start out together, but in several days individual differences begin to tell; since each progresses at his own rate, many are working on separate experiments. At the end of a few weeks, their pace in covering the outline slows, due either to lack of ability to carry on, or interests carrying them over into more fertile fields; this is the opportune time to review the material, exchange experiences and further develop certain principles. After several weeks of individual experimenting, the class reviews the unit. This review can be carefully developed into the preview for the next unit.

The applied science equipment includes a large laboratory containing six large tables, plenty of cupboard and drawer space, with much freedom for experiments. For the previews or reviews, a small adjoining classroom is available. There is no text, but a large library of books, ranging from junior high school general science books and more popular scientific reading to chemistry and physics texts, is used. Current magazines, clippings, pictures, bulletin boards and other similar devices aid in the attaining of the objectives. Spreading across so many fields, permanent equipment is an impossibility. Some equipment is borrowed from the science department for a short time. Much is being constructed, for homemade materials that can be cut in sections to show their operation are the best, as we are dealing with pupils who like to "learn by doing."

With respect to the procedure of the course from an instructional point of view, much has been said in discussing the content. First the fundamental principles of science necessary to explain the pupil's experiences were formulated. Following this, specific objectives and an outline of the probable course of study were formulated, having the units revolve around the fundamental principles. The learning process was described in terms of activities. This consists of previews, demonstrations, experimentations, responses, review and integration.

With regard to the method of presenting applied science, much experimentation has been done. At first it was believed that the type of pupil with which the course dealt, that is, those desiring to translate thoughts into "doing things", would be more interested in and capable of experimenting. After trying many methods of presentation and testing the relative effectiveness of each, it was found that a balance of five types is the most effective. The major emphasis is on pupil demonstration, with notes by the rest of the class, and individual pupil experiments briefly written up. The minor emphasis is on teacher demonstrations for the short previews and reviews in each unit, with directed observation and experimentation for out-of-class activities. Thus far much of the formal science content, equipment and activity has been abandoned.

A six point testing program includes:

First, a list of pupil needs as seen by themselves, teachers and others.

Second, two interest tests were made up, one requiring the selection of favorite science topics, such as electricity, acids, astronomy, buying, light, airplanes, etc. The other interest test was based on the units and consists of selecting activities in which they would like to participate, such as removing stains, making solutions, taking, printing and developing pictures, making a good toothpaste and so on; one hundred and forty-four activities in all. These were given the first week of the course and were given again the last. Further analyses of pupil interest were made by discussing their interests with them and observing their choice of experiments.

The third point in the testing program was concerned with pupil abilities. The experiments were graded, those they chose themselves were closely watched, for abilities are peculiar to each group, and an individual record was kept of each pupil.

Fourth, their ability to generalize scientific principles with respect to their experiences was tested at the end of the course by means of a test which required the pupil to match a list of scientific experiences with underlying principles.

Fifth, ability to use the scientific method was tested by having the pupils state practical problems, experiment, observe, analyse and then come to a conclusion.

Finally the course was evaluated from pupil and school opinion. A few apparent values follow:

Pupil Value:

1. A spontaneous interest is produced about the pupil's experiences and activities.
2. A felt need is satisfied with respect to science.
3. An opportunity is given for the pupil to explain his environment more fully and derive satisfaction from it.
4. Different abilities are compensated for in a personal way since each works at his own speed.
5. Teacher-pupil relationship is improved by a closer contact.
6. The pupil is doing things, translating words into actions.
7. The pupil will appreciate the material learned in science when it is applied directly and used at once in other work.

School Value:

1. There is freedom from subject matter restraint.
2. The emphasis is changed from subject matter to experiences.
3. The procedure is adaptable to any science course.
4. Science content may be selected by use of interest tests.
5. An approach to consumers' science is presented.
6. The course may be used as part of a core curriculum.

There is a definite relationship between applied science and the last two items, consumers' science and core curriculum. Having successfully broken down the barriers between subjects, and recognizing the trend toward a further integration of experiences of analyses of desirable and valuable relationships between personal business problems, a consumer education course and applied science, have been made. The result of these analyses, it is hoped, will lead to a development of a larger, broader area of experience for student appreciation of life.

While still in an experimental stage, the pupil response, results and comments have been so satisfactory that there is justification for such an early publication of trends and preliminary results. Final results are impossible since in its essence applied science is unique for each group, due to the variability of pupil needs, interests and abilities. Applied science is making a definite contribution to the group with which it deals and is taking a definite part in reorganizing the curriculum in order to furnish useful experiences and to develop an integrated pupil.

Reflect upon your present blessings, of which every man has many; not on your past misfortunes, of which all men have some.—*Charles Dickens.*

THE THIRTY-SIXTH ANNUAL CONVENTION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

By Harold Metcalf

Oak Park, River Forest High School, Oak Park, Illinois

The thirty-sixth annual convention of The Central Association of Science and Mathematics teachers was held on November 26th, 27th, and 28th in St. Louis, Mo. All of the meetings were held in the Coronado Hotel. Ample accommodations were furnished for the personal welfare of the members who attended as well as for the placement of the exhibits and the rooms for the various meetings. President O. D. Frank and local arrangements chairman W. R. Teeters had spent many days in preparation for the meetings and were rewarded by the enthusiastic group which turned out.

The executive committee met on the afternoon of November 26th and the board of directors went into session at eight in the evening. Reports were received from the various committees and W. R. Teeters told of the plans of the local arrangements committee. Those in attendance were; Pres. O. D. Frank, Katherine Ulrich, W. R. Teeters, Charles S. Webb, W. W. Hart, Walter G. Gingery, J. S. Georges, Marie Sangernebe Wilcox, N. A. Neal, Walter H. Carnahan, G. T. Franklin, W. F. Roecker (proxy for H. Clyde Krennerick) and Harold H. Metcalf (secretary pro tem).

THE FRIDAY MORNING GENERAL SESSION

The Soldan High School Instrument Ensemble entertained the members of the association as they gathered for the general session. Pres. O. D. Frank, in his gracious and friendly manner, thanked the various members and the director. He then introduced Supt. Henry J. Gerling of St. Louis who extended a welcome and best wishes for a successful meeting. Supt. Gerling stressed the importance of rational scientific thought in the affairs of daily life and of a scientific interpretation of life which does not rob it of its spiritual values. Mr. Ira C. Davis whole heartedly accepted the cordial welcome for the members of the association and thanked St. Louis for providing an opportunity for professional growth, for making it possible to renew old friendships and make new ones, for the multitude of new experiences possible at the convention and in the city, and for the increase in membership that would result from the meeting.

Most of the speakers on both the general and section programs had prepared manuscripts which the members unable to attend the convention may read in this and in subsequent issues of the journal. The whole program of the convention was exceptionally interesting and stimulating. Only a brief summary is attempted in this report.

Dr. Peter Blos, who had studied and taught in a number of European countries before coming to America, talked on Science in the Southland. He divided his discussion into three parts. In the first part, he told of the invasion of science into the grades in many localities and in some state wide programs in the south. The importance of a growth of this movement was stressed. Dr. Blos believes that the psychological understanding of the pupils should rank in importance with the material taught, that the interests and attitudes of children in things and events around them should be fostered, that scientific values should be cultivated whatever may be their form, and that scientific mindedness on the part of the child should be encouraged at every opportunity. In order to carry out such a program intelligently, the grade teacher of the future must have a more thorough training in science.

Dr. Blos then discussed the search for the vital objective in high school science. He stated that in the past too much emphasis had been placed on the assimilation of knowledge rather than on the effects of knowledge on personality. Education for life should more and more become the underlying basis for our educational philosophy. In General Science especially should the text become a reference book, the class period not a lecture period but a period in which attention is given to the solving of problems. The subject matter should be chosen as the year progresses on the basis of student interests rather than planned ahead of time by subject matter experts. Dr. Blos related some interesting experiences in group projects in which many problems arose for the students to solve.

The inertia of the high school science curriculum has been due to the picturing of the child as an incomplete adult rather than as a complete individual at his level. Many of the texts are simplified college texts and too many of the teachers simplified college professors. The dynamic of subject matter or the adjusting of the subject matter to the needs of the pupil should become the ideal of the future.

Superintendent John L. Bracken of Clayton, Missouri discussed How Science and Mathematics Are Taught in Missouri Schools. He first gave statistics to show the changes that were taking place in high school curricula. Of the 673 first class high schools in the state, only 628 teach algebra, 533 advanced algebra, 111 trigonometry, 495 advanced arithmetic, 627 general science, 348 biology, 106 physiology, and 229 physics. General Science and Biology are on the increase while physiology is on the decrease. In mathematics, the problems confronting the educator are: first; at what level should mathematics first be taught; second, how much mathematics should be required; and third, how can mathematics teaching be improved? In science, the greatest changes are needed in the elementary school curriculum.

Mr. Bracken criticized the science and mathematics teaching of the past as having stressed facts rather than the appreciations, attitudes, and perspective that the student might gain. Scientific and mathematical principles remain the same but new direction should be given to their application. There has been too much emphasis on the use of ballistics in war, too much poverty, human wreckage, unemployment, red ink, and misery. Science and mathematics do not possess many of the attributes given to them by the man in the street. More religion is needed to help solve the problems of life. The question of what values in life are to be most desired must first be answered and then every effort made to achieve those values.

Seeing the Invisible was the subject of Mr. Herbert H. Johnson of the Eastman Kodak Company. Mr. Johnson showed a slide made from the first photograph done by Mr. Draper of New York University which required two and one half minutes of exposure in bright sunlight, and then one from a photograph taken in a completely dark room which required an exposure of one second. The use of the x-ray was illustrated by a full length photograph of a man on a film 32 by 72 inches and by photographs of steel castings which showed the presence or absence of flaws without injury to the castings. The discovery of changes made in the paintings of old masters by use of the x-ray was also illustrated. Photography by the use of the ultra violet has practical value in the search for forgeries in legal documents. Other slides showed how gases given off by charred paper not only effected a film in contact with it but showed the printing which could be made visible in no other way. A simple device was shown which makes it possible to attach the cameras to a microscope and do photomicrography work. The use of the infra red in photography was illustrated by a slide

showing two hot flat irons on either side of a statue in a perfectly dark room giving great detail on a film sensitive to infra red rays. In the case of the photograph of the men in an auditorium, the room was flooded by tungsten lamps which were behind filters which removed all of the spectrum except the infra red. The best example of the great detail and distance made possible by infra red photography is the picture taken on the last stratospheric flight at an altitude of 23,000 feet which showed a distance of 300 miles and a horizon line that would take away all doubt that the earth is a sphere.

BIOLOGY SECTION

The biology section was called to order November 27, 1936 at 2:00 P.M. by R. B. Simon. The secretary, Lillian Bondurant; and Vice Chairman, John W. Kendrick, were also present.

The nominating committee, consisting of the following members, Joel W. Hadley, Indianapolis, Indiana; and A. G. Grosche, Waukegan, Illinois, was appointed.

The first speaker was Dr. J. J. Bronfenbrenner, Professor of Bacteriology and Immunology, Washington University Medical School, St. Louis. His subject was "Bacteriophages" (Illustrated). An early hypothesis was formed that agents for destroying bacteria, bacteriophages, entered the bacterium, multiplying to such numbers that the bacterium burst and thus set free more of these agents to enter other bacteria. Dr. Bronfenbrenner set forth his own thoughts and views which have been checked and controlled. In a bacteria culture, one half of which was subjected to bacteriophages, the bacteria in that half became fewer in number. Those remaining became larger, both in length and in circumference. On these enlarged bacteria, stains were used so that the ectoplasm and endoplasm could be distinguished from one another. It was noticed that the cytoplasm became very irregular or granular which suggested its being digested. If it was digested then there must be products of digestion. To find and determine these products, an inorganic medium was used so that any nitrogenous material present would then come from the disintegration of the cytoplasm. There was found to be a high amino-nitrogen ratio. When the bacteriophages enter the bacteria and digest the cytoplasm, hydrolysis takes place. The water entering causes the bacteria to swell and break. When water was prevented from entering, the bacteria did not enlarge.

The second speaker was Dr. W. J. Robbins, Professor of Botany, University of Missouri, Columbia. His subject was "Plant Hormones" (Illustrated). Dr. Robbin's paper will appear in full in an early issue of the Journal. He illustrated how tropisms are explained from the standpoint of hormones. In explaining phototropism, oat coleoptiles were used for experimentation. The hormones are concentrated at the growing tip. These hormones move away from the light and pass down the shaded side of the stem. The cells along this side enlarge, thus bending the stem toward the light.

The third speaker was Dr. Peter Blos, teacher of Biology, Metairie Park Country Day School, New Orleans, Louisiana. His subject was "Biology in the Southland." Dr. Blos's paper will appear in full in an early issue of the Journal.

The fourth speaker was Arthus O. Baker, Teacher of Biology, John Marshal High School, Cleveland, Ohio. His subject was "The Visual Route to Education." This paper will appear in full in an early issue of the Journal. Teaching is lighting a lamp and not filling a bucket. We are picture minded, the learning process must be dramatized and learned in wholes and not in parts. The system used in Cleveland is called the Jones Rotary

system. The advantages of the system as set forth are: (1) Teachers schedule is reduced. (2) Teachers have time to prepare. (3) Monotony is avoided. (4) A visual route to education is made possible.

The report of the nominating committee was accepted. The section officers for 1937 are: Chairman, John W. Kendrick, Arsenal Technical High School, Indianapolis, Indiana; Vice Chairman, Harold W. Evans, Hartwell High School, Cincinnati, Ohio; Secretary, Lillian Bondurant, Oak Park and River Forest Township High School, Oak Park, Illinois.

LILLIAN BONDURANT *Secretary*

CHEMISTRY SECTION

The chairman, Allan Stacy, called the section to order at 2:00 P.M. and appointed a nominating committee of the following members: G. T. Franklin, G. K. Peterson, and Leonard Dodd.

Integration of Personality by Pandemic Chemistry was discussed by Ernistine Long of Normandy High School of St. Louis, Missouri. She stressed the importance of the teacher-pupil relationship in cooperative living in the classroom. The students help to plan the work to be studied and the usual classification of subject matter is abandoned. Historical incidents are lived through by the students. Educational experiments find the teacher the variable element who is in need of integration.

Kenneth E. Conn of Bloomington, Indiana, discussed the Point System of Grading as Means of Securing Greater Pupil Participation in High School Chemistry Classes. The present system of grading lacks objectivity and is not a measure of success. Since some system is demanded, the evils should be reduced to a minimum. The explanation of the point system as a means of solving this problem appears in Mr. Conn's paper which is being published in a forthcoming issue of the Journal. Recognition of pupil participation aids greatly in motivation and results in increased responsibility on the part of the pupil.

Jesse L. Van Horn of Lincoln High School of Cleveland, Ohio was elected chairman of the section for the coming year, R. E. Whitney of Marshall High School of Chicago, Illinois was elected vice chairman, and Ernistine M. J. Long of Normandy High School of St. Louis, Missouri, was elected secretary.

A. E. Goldstein, of the department of chemistry in Washington University, discussed the Correlation Between High School and University Chemistry. He stated that since such correlation would lead to standardization that it was neither advisable nor feasible. He outlined an alternative plan which is explained in his paper.

Dr. Paul A. Krueger of the Mallinckrodt Chemical Company told of some interesting anecodotes in the chemical manufacturing industry. The methods of increasing yields are most important but they are usually kept secret. The stories of the gall nut, the effect on photographic emulsions of a compound found in some gelatin that came from cattle that had eaten the mustard plant, and the use of such by products as the spent cloves which were left after the oil had been extracted, were very interesting.

The papers were all very enlightening and should be read in the journal to get the value from them.

R. E. WHITNEY, *Secretary*

ELEMENTARY SCIENCE SECTION

The fifth meeting of the Elementary Science Section was called to order November 26, 1936 at 2:00 P.M. in the Coronado Hotel, St. Louis, Mis-

souri by Lillian Hethershaw, chairman. The Secretary, Glen Blough, was not present. Geraldine Shontz, Vice-Chairman, acted as secretary.

The minutes of the last annual meeting were read by the secretary pro tem and approved.

The nominating committee, consisting of the following members, Elizabeth Downhour, Indianapolis, Indiana, L. M. Dougan, St. Louis, Missouri, and Ellsworth S. Obourn, Clayton, Missouri, was appointed.

An interesting and instructive program was given as follows:

The first speaker was Illa Podendorf, Supervisor of Elementary Science, Newton, Iowa. Her subject was "A Science Unit for the Fourth Grade—Rocks and Minerals in Everyday Life."

The understandings developed in a unit on this subject are:

1. The whole earth is made of rocks and minerals.
2. They are of great industrial value to man.
3. Man has made use of them all through history.
4. Man is making more use of them now than ever before.

Miss Podendorf had much interesting material that her pupils had worked out in the unit.

The second speaker, David W. Russell, National College of Education, Evanston, Illinois, spoke on the subject—"Children's experiences in Elementary Science Related to Problems of Current Living—Fire and Air."

Mr. Russell contends that no matter what philosophy of Science Education or techniques of teaching a science teacher has there are certain practical knowledges that are useful in the living and the health habits of children in the upper elementary grades. Through pictures he illustrated experiences children had had in the study of "Fire and Air," under his supervision. He suggested many new and practical ideas to the teacher for developing these knowledges for the elementary grade child.

Mr. Ellsworth S. Obourn, John Burroug School, Clayton, Missouri was the third speaker. In his talk on "What Can the Junior High School Teacher of Science Expect from the Elementary Pupil," he gave these pertinent suggestions. The elementary science child should, (1) be prepared to make practical adjustments to science situations at his level. (2) Should have a method of attack in problem solving. (3) Should have some functional understanding. (4) Should develop a good science vocabulary for current living.

The fourth speaker, Miss Clara M. Heising, Field School, St. Louis, Missouri, spoke on the subject, "How to Present the Topic of Insects to a Fifth Grade."

Miss Heising makes use of any available incident in her school room to motivate the study of insects. She gave some very helpful suggestions as to how any teacher could recognize such opportunities.

The last speaker Mr. Kennon, St. Louis, Missouri zoo, gave many interesting facts on "The Home Life" of our most common birds.

The nominating committee presented recommendations for officers for the next year as follows:

Geraldine Shontz, chairman, Indiana State Teachers College, Terre Haute, Indiana; David Russell, Secretary, National College of Education, Evanston, Illinois; Mary Melrose, Vice Chairman, Supervisor of Elementary Science, Cleveland, Ohio.

It was moved, second and voted that the report of the nominating committee be accepted.

The meeting adjourned at 4:30 P.M.

GERALDINE SHONTZ, *Secretary pro tem*

GENERAL SCIENCE SECTION

Miss Alma Thomas called the meeting to order and appointed the nominating committee consisting of Lawrence H. Fuller, of Milwaukee, Wisconsin, Ira Davis of Madison, Wisconsin, and Bertha Oechsle of Cincinnati, Ohio.

The first speaker, Henry P. Harley of Cleveland, Ohio, discussed the subject of How To Keep Forty Busy. A teacher finds difficulty in adapting progressive ideas developed in selected groups to the conditions of the conventional classroom. The teaching program must emphasize individual instruction and development of social understanding and participation. "A few thought inspiring suggestions are written on the board. The teacher gives assistance to those who have language difficulties, poor working habits, who are under privileged, and who need help in how to study. The materials used by the science teacher can be adapted very readily for purposes of experience in social participation. They must not be the cold storage variety."

Mr. L. F. Pinkus of St. Louis demonstrated a home made microprojector that he had built. The entire machine was built from materials that cost less than ten dollars. By the use of the projector he was able to throw images of living organisms on the screen. Several slides were shown with it and then a general discussion of the construction of the machine was held.

The nominating committee presented Carl F. Hanske of Emmerich Manual High School of Indianapolis, Indiana for chairman, Theodore J. Kuemmerlein of the Boy's Technical High School of Milwaukee, Wisconsin as vice chairman, and Herbert A. Grabau of Des Moines, Iowa as secretary. These officers were elected unanimously.

Herbert H. Johnson of the Eastman Kodak Company discussed Recent Developments in Color Photography. First, he gave an illustrated talk on the theory of color reproduction; secondly, a discussion of some of the new color slides that it is possible to make; and third, a reel of the new Kodachrome moving picture film.

The theory of color film was demonstrated on some very excellent slides. The new film that is now available for several still cameras makes possible a remarkable reproduction of color, depth, and detail at a very nominal cost. This if possible because the silver in the film is replaced by colored dye during the 27 operations necessary to process it. The possibilities of the film for classroom use are unlimited.

THEODORE J. KUEMMERLEIN, *Secretary*

GEOGRAPHY SECTION

The section was called to order by chairman Virgil O. Petty. Katherine Ulrich, Viva Martin, and Thomas H. Finley were made the Nominating committee.

Edna M. Gueffroy gave an illustrated lecture on the subject of Home Gardening in Fairbanks, Alaska. Her paper and some of her photographs will appear in the journal.

Dr. Lewis F. Thomas, head of the Geography Department of Washington University in St. Louis, gave An Analysis of the Geographic Aspects of the South Seas. He told of the geology of the islands and the seas, described the vegetation and the climate, and gave an idea of the stage of culture of the inhabitants.

George M. Park, M.D. then took us on a Journey through the South Seas. A mere sketch will have to suffice as the reels covered a range of many miles, of towns on islands, of lakes, of vegetation, of men in their dances

(religious), of girls in their dances (entertainment), of transportation, and of mountain grandeur. We saw Java with its town of Sarabayn showing the Indian influence in its buildings; the rich vegetation; and the steam released from volcanoes to prevent explosions. We saw Sumatra in the frequent rains and bright sunshine and beautiful Bali, the tropical garden of Eden. Most gorgeous of all were the mountains, canyons, falls, and glaciers of New Zealand.

Rachel Hunt of Forest Park School of Fort Wayne, Indiana then gave an illustrated lecture on Our Cereal Crops, A Method of Teaching a Unit in the Seventh Grade. An outline of the unit appears in the Journal.

John Y. Beatty of Chicago then explained How to Make Geography the Most Popular School Subject. He would make the subject more appealing by having the pupil experience the thrill of geographic discovery by actually studying in the field. He described a trip on the Fox River in Illinois, taken with two boys, covering seven days. This trip will appear in book form and include chapters on boats, botany, birds, source of the river, mouth of the river, power of water, law of streams, highways, and legal rights.

The recommendations of the nominating committee were unanimously voted. Frederick J. Breeze of Fort Wayne, Indiana is to be chairman, Helen Turner of Oak Park, Illinois is to be vice chairman, and Ethel L. Mills of St. Louis is to be secretary.

ETHEL L. MILLS, *Secretary*

MATHEMATICS SECTION

Mr. C. J. Leonard called the meeting to order and appointed Walter Carnahan and Alfred Davis on the nominating committee.

Dr. Maurice L. Hartung spoke on Evaluating Appreciation of the Cultural Values of Mathematics. The paper stressed three points: First, the need for clarification of the objectives of mathematics in terms of the changes in behavior we want to develop; second, the need for evidence that we are achieving these objectives; third, the belief that if we really attack these problems we can make progress toward evaluating objectives which have usually been classified among the intangibles. Mr. Hartung illustrated these points by giving a tentative statement of some objectives related to logical reasoning, and by some experimental test items which are being used to get evidence about reasoning ability.

Dr. Anna A. Stafford, instructor in Mathematics, University of Nebraska, read a paper on Adapting the Curriculum to our Era. The mathematics curriculum is encumbered by a lot of antiquated material which we preserve for many reasons, not all justified. Modern scientific and social knowledge is clamoring for more mathematics not necessarily of the historical type. We must discard drill for method and content. The high school curriculum must include elements of statistics, calculus, number theory, non-Euclidian geometry, and advanced algebra which are too difficult for the high school student only because they have never been put into form suitable for consumption for the adolescent. The general public exhibits a real hunger for pure mathematics; at the same time it refuses to countenance the unpalatable diet offered in our schools. The schools are failing to respond to a real human need of this generation.

The following officers were nominated by the committee and elected. Chairman, Vivian B. Ely, George Washington High School, Indianapolis, Indiana; vice chairman, Harold E. Spross, Central High School, St. Louis, Missouri; Secretary, Eleanor E. Booher, Oak Park High School, Oak Park, Illinois.

Dr. J. S. Georges of Wright Junior College of Chicago discussed Mathematics in the Junior College. He considered the problem: What mathematics should a college student in general education have? He then told of the experimental work that has been done at Wright Junior College during the past three years in order to determine the units of instruction which should be included in such a course in Freshman Mathematics.

The meeting was then adjourned.

ELEANOR E. BOOHER, *Secretary*

PHYSICS SECTION

The section meeting was called to order by Charles L. Brosey, chairman, who selected the following members of the nominating committee; F. E. Goodell, J. V. Skinner, and W. F. Roecker.

James P. Davis of Clayton High School of Clayton, Missouri then discussed Some Modern Methods for the Improvement in High School Physics. He emphasized the stimulation of student interest through a variety of approaches to the problems of the subject. He told how to overcome difficulties with lower groups and with larger groups.

Professor Frank W. Bubb of the Mathematics Department of Washington University of St. Louis then talked on the Influence of Geometry upon the Physical Sciences. He told of the need for a unified, basic, mathematical statement which will include all space and time relationships.

The nominees of the committee were then elected unanimously. N. A. Neal of East Technical High School of Cleveland, Ohio was elected chairman, James M. Althouse of Soldan High School of St. Louis was made vice chairman, and James P. Fitzwater of Lakeview High School of Chicago was elected secretary.

Professor Ralph K. Watkins of the University of Missouri then predicted the Future of the Special Sciences in the Senior High School. He first stated that secondary science must serve these ends; general education, professional, preliminary training, and service level training. The trend will be toward science education that more nearly fits the life experience of the student. Some of the questions that must be answered are: First, are we sugar coating when we generalize; second, does sugar coating serve an end; and third, are practical values of most importance in secondary science?

James M. Althouse of Soldan High School of St. Louis then talked on the subject of Visual and Audial Effects of Filter Circuits upon Recorded Sound. He described the superiority of the electrical ear (the microphone) over the human ear. He also discussed the possibilities of filter circuits in various types of tone control.

N. A. NEAL, *Secretary*

THE ANNUAL RECEPTION AND ANNUAL DINNER

After the section meetings in the afternoon, much interest was displayed in the various, well planned exhibits of the textbook and scientific apparatus companies. At about five P.M. the members and their wives and husbands met in the lounge of the Coronado Hotel to exchange friendly greetings before the annual dinner. They then moved on into the Club Caprice where the Beaumont High School Girls Novelty Orchestra under the supervision of E. P. Stamm entertained with delightful music during the dinner. Theodore D. Kelsey, who acted as toast-master, then introduced R. E. Strickler who sang the Desert Song and Ole Man River. These were received so heartily that he responded with My Big Base Viol. President O. D. Frank, who had been honored previously by the presentation

of luscious apples to all attending the convention, then told of the significance of the cover on the yearbook which was drawn by Miss Elizabeth Isenbarger. He also asked the representatives of various states to show hands and found a wide geographical distribution. He then asked everyone to write his name, his month of birth, his birth place, his profession, and his hobby. Mr. Frank promises some interesting information in a future issue of the Journal. Miss Katherine Ulrich then introduced the speaker of the evening, Mr. John Y. Beatty, by telling some interesting anecdotes which indicated that Mr. Beatty was an all around scientist and also a good fellow.

Mr. Beatty took his listeners out to the home and experimental gardens of Luther Burbank where he had spent a year while writing the autobiography of Luther Burbank. Burbank was an untiring worker. The changes that he was able to bring about in plants were simple but not easy. He was purposeful in his work, kindly in his associations, and alert to qualities in plants which were not evident to the casual observer. He worked with thousands rather than with one or two specimens. An example of his persistence and his method of developing new plants is illustrated by his work with the calla lily. He first made many crosses of lilies to get variation. None was sweet smelling. Finally, he had an acre of lilies of many varieties. One evening in going through the beds he smelled a lily sweeter than the rest; he searched for it until he found it; and from this one lily he developed the flower as we find it today.

Mr. Beatty then told many interesting things about ants. He has made many discoveries in this field which has become a hobby.

ANNUAL BUSINESS MEETING

The Annual Business Meeting was called to order at 8:30 A.M. on Saturday morning, by President O. D. Frank.

Mr. Turton, who had attended every previous meeting of the association since 1901, was unable to attend the convention at St. Louis. The nec ology report which had been prepared by Mr. Turton and Mr. Charles Leckrone was read by the secretary. It appears in this issue of the Journal.

Mrs. Martin moved, it was seconded and carried that the following message be sent to Mr. Turton.

"We miss your friendship, your humor, and your inspiration. Our meeting has not been complete without you." From your many friends in the Association.

Mrs. Wilcox made her report as chairman of the membership committee. She commended the various state chairman for their splendid work and asked for greater cooperation on the part of every member of the association in order to make the Association more widely known.

President Frank spoke highly of Mrs. Wilcox and thanked her and her committee for their efforts.

Walter H. Carnahan and Franklin Frey audited the books of the treasurer, Ersie Martin, and reported them correct. The bank balance on Nov. 27, 1936 was $557.99.

Mr. Gingery then gave the report of the nominating committee. He spoke of the importance of good officers to the success of the Association and told of the great care that had been exercised by the committee in selecting nominees. Mr. Authur O. Baker of John Marshall High School of Cleveland, Ohio, Mr. Ira Davis of the University of Wisconsin of Madison, Wisconsin, Miss Lillian Hethershaw of Drake University of Des Moines, Iowa, and Mr. C. J. Leonard of Southeastern High School, Detroit, Michigan were nominated as Directors, Mr. R. B. Simon of the

Western Reserve Academy of Hudson, Ohio was nominated as Vice President, and Mr. W. R. Teeters of the St. Louis, Missouri Public Schools was nominated as President. It was moved, seconded, and carried that these officers be elected unanimously.

Mr. J. P. Fitzwater gave the report of the resolutions committee which was accepted in an amended form.

The report of the conservation committee was distributed in printed form and appears in this issue.

Mr. Jerome Isenbarger gave the report for the committee on the place of meeting. The association had received invitations from Chicago, Detroit, Cincinnati, Cleveland, and Milwaukee. Mr. Isenbarger stated that, although it had been customary to meet in Chicago every alternate year, exceptions had been made. Cincinnati had made every effort to impress the Association with their sincerity in promising every possible aid if the convention were to come there in 1937. Cincinnati was presented by the committee as the place for meeting and it was moved, seconded, and carried that the Board of Directors be asked to approve of the selection.

Mr. Teeters deeply thanked the Association members for electing him to the presidency and promised to immitate past presidents in doing his best to do the job well.

Mr. Roecker gave an incomplete year book report indicating that income would be larger than last year and that there would be a balance of approximately $48.00.

The Journal committee reported a very successful year of operation. A summary of the good work of Mr. Roecker and Mr. Warner appears elsewhere in this issue.

Mr. Goodell moved, it was seconded, and carried that the following resolution be adopted:

"The association expresses its hearty appreciation for the excellent service of the editor, Mr. Glen W. Warner, and the business manager, Mr. W. F. Roecker, of the Journal. Largely through their efforts the Journal has prospered during these years of depression and the bonded indebtedness has been paid off."

Mr. Webb stated that a few years ago the problem of life membership had been discussed but nothing had been done after the committee had reported. Mr. Webb moved and it was seconded and carried that a new committee be appointed to look into the problem of life memberships.

It was moved and seconded and carried that the meeting adjourn.

THE SATURDAY MORNING MEETING

The Vashion High School Choral Club under the direction of C. S. Tocus entertained with negro music. The club was called back a number of times by an enthusiastic audience.

President O. D. Frank introduced Professor Theodore Yntema of the University of Chicago who spoke on the Relation of Mathematics to Economics. He pointed out that a large number of students, who plan on taking social science in college, are not acquainted with the need of a knowledge of mathematics nor are they given the mathematics in high school that can be applied in economics. Professor Yntema described in detail some of the concepts that were necessary to an understanding of economic theories.

Professor Ralph C. Bedell of the State Teachers College of Kirksville, Missouri talked on the Factors Influencing Success in Science and Mathematics. Many students profit by the prescribed course of study, but many others drift into work for which they are not fitted. The curriculum is usually made for the average student. Professor Bedell told in detail of

the methods used by him in helping to guide students into courses and professions for which they are equipped mentally. His paper appears in this issue.

Dr. Gustave Lippman, M.D. of St. Louis, then read a paper on the Amorality of Science. Dr. Lippman decried the fact that the industries had done so little to correct the working conditions in their plants in order to prevent occupational diseases. He held up the medical profession as an example of high ethical standards. Preventative medicine has helped greatly in cutting away many hazards to health which previously existed. The industrialist could well afford to follow this example and thus preserve the health and happiness of thousands of workers.

THE SATURDAY AFTERNOON MEETING OF THE BOARD OF DIRECTORS

All newly elected officers, members of the Board of Directors, and other officers of the association met at 12:30 to discuss plans for the 1937 convention.

A formal meeting of the Board of Directors was held immediately afterwards. Mr. Isenbarger reported the findings of the committee on place of meeting. It was moved, seconded, and carried that the 1937 convention be held in Cincinnati, Ohio. It was moved, seconded, and carried that Harold H. Metcalf be elected secretary and treasurer of the association for the coming year.

Mr. Ira Davis moved, it was seconded, and carried that an honorary life membership be given to Mr. W. W. Hart who has served the association so faithfully these many years.

It was moved, seconded, and carried that the officers of the association be listed in each issue of the Journal. Mr. Warner is to use his discretion in the matter of where and how they are to be listed.

It was moved, seconded, and carried that Mr. Warner announce the retirement of the debentures by the Journal in the January issue of the magazine.

Mr. Georges urged that the members of our Association help to advertise its activities by making announcements at club meetings and at other opportunities.

It was moved, seconded, and carried that the Board send a resolution to Mr. Martin commending him for his work as treasurer. The meeting was adjourned.

The combined report is respectfully submitted.

HAROLD H. METCALF, *Secretary*

REPORT OF THE NECROLOGY COMMITTEE

The Necrology Committee reports the passing of five members and friends. Ross B. Wynne, our Secretary Joined the Association in 1927. He was born at Princeton, Missouri, June 13, 1891. He obtained his education at Northwestern University, graduating in 1916. In 1925 he began his service in the Chicago Public System as teacher of Botany in the Crane Technical High School. In February 1928 he became an Instructor of Botany in Crane Junior College and in September 1934 he was transferred to the Woodrow Wilson Junior College.

Mr. Wynne was an enthusiastic student in his chosen field. During the decade following the war he continued graduate work in the Botany Department of the University of Chicago completing twenty-four majors toward the doctorial degree. As a teacher he was extremely patient and sympathetic, ever ready to serve his students. Besides being a member of our association he was a member of the Botanical Society of America,

The Ecological Society of America, and The Association for the Advancement of Science.

W. C. Hawthorne joined our Association in 1904 and for the remainder of his teaching was an active member of the Physics Section. He was born in Maple Park, Ill., and graduated from the University of North Dakota. He also studied at the University of Chicago and in 1901 began his teaching at the Harvard School for Boys, Chicago. Later he was an Instructor at the Central Y.M.C.A. College, Chicago for several years. For twenty-three years he taught Physics in the Crane Technical High School and Junior College. When he retired two years ago he was Dean of the Premedic School at the college. He was beloved by all his friends and pupils and was an enthusiastic worker in his chosen field, Physics.

A. C. Stillhamer was a charter member, joining the Central Association of Physics Teachers, the predecessor of our present Association, in 1902. In 1908 he moved to Bloomington, Ill., where he died last January. He was a great friend of the association and its journal. He showed this by becoming one of the journal debenture holders which he refused to cash during his life. His department was Physics.

Adrian A. Worun of the Senior High School, Racine, Wis., died during the past year. His name first appears in the Year Book of 1921 and continued thereon until two years ago. His department was Biology.

Professor Herbert Brownell of the University of Nebraska died in September of this year. Altho not a member of our association he was a great friend and attended several of its meetings taking active part in the discussions. He took a very active interest in our journal and for a few years was on its staff as a department editor. For these reasons we mention him in our report.

CHAS. M. TURTON
CHAS. LECKRONE

REPORT OF THE CONSERVATION COMMITTEE

Members of the Committee: Wm. G. Vinal, Western Reserve University, Cleveland, Ohio; O. D. Frank, School of Education, University of Chicago, Chicago, Illinois; J. L. Cooprider, Central High School, Evansville, Indiana; W. R. Teeters, Board of Education Building, St. Louis, Missouri; Louis E. Hildebrand, New Trier High School, Kennilworth, Illinois; Fred Schriever, Chairman, Boys' Technical High School, Milwaukee, Wisconsin.

This committee, appointed November 29, 1930, has five times reported its findings. With some change in membership it is to continue the study of the question of Conservation Education in the Secondary School curriculum.

We shall give two examples of conservation activity taken from Wisconsin, as we happen to be better acquainted with conservation in this state. No doubt other states carry on similar activities.

A. *Summary of Conservation Activities in Wisconsin.* The passage of the Wisconsin Conservation Education Law in 1935 placed the responsibility of conservation education on the State Department of Public Instruction. In a report this department sums up its conservation activities:

1. State law recently enacted, specifies Conservation of Natural Resources as a required subject to be taught in all schools.

2. A state high school supervisor has been appointed to direct this work and to supervise curriculum construction.

3. Small group conferences of superintendents, principals, and supervisors have been held throughout the state this fall for a full discussion of the problems involved.

4. Both teacher and pupil helps will be issued from the State Department.

5. The Conservation Commission is cooperating fully with the State Department of Public Instruction.

6. A state committee is being formed representing the various organizations and agencies interested in conservation in the state. The purpose of this committee is to formulate a state program of conservation.

B. *Conservation Activity.*

1. As an example of conservation activity we cite the exhibit at the recent Convention of Wisconsin Education Association, working in conjunction with the Izaak Walton League, State Conservation Department, United States Forestry Service and the State Superintendent of Public Instruction.

2. A Conservation Education Planning Association has been set up. (Details are found on the added report.)

C. *Conclusions.* The findings and conclusions of our committee have been given in our previous reports. We shall mention only three:

1. Conservation should, and may easily, be correlated with other subjects;—it need not be taught separately.

2. Every school should take interest in some phase of conservation, even though it be but little. Schools should avail themselves more of help to be derived from local, State, and Federal conservation agencies.

3. Conservation is not conversation; it is a way of life. It must be learned and promoted by performance rather than by reading or discussion. It is a wholesome combination of study and activity.

Respectfully submitted,

FRED SCHRIEVER, *Chairman*

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

NOTE. Persons sending in solutions and submitting problems for solution should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solutions.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

1460. *Proposed by H. R. Mutch, Glen Rock, Pennsylvania.*

If P, Q, and R be the pth, qth and rth terms of a geometric progression, then $P^{q-r} \cdot Q^{r-p} \cdot R^{p-q} = 1$.

Solution by Maxwell Reade, Brooklyn, New York.

If the first term of the Geometric Progression is a, and common ratio is m, then

$$P = am^{p-1},\ Q = am^{q-1},\ R = am^{r-1}, \text{ and}$$

$$P^{q-r} \cdot Q^{r-p} \cdot R^{p-q} = (am^{p-1})^{q-r} \cdot (am^{q-1})^{r-p} \cdot (am^{r-1})^{p-q}$$

$$= (a^{q-r+r-p+p-q}) \cdot \left[m^{(p-1)(q-r)+(q-1)(r-p)+(r-1)(p-q)}\right]$$

$$= a^0 \cdot m^0 = 1$$

as was to be proved.

Solutions were also offered by David Blakewell, University of Illinois, Julius Freilich, Brooklyn, New York, A. R. Haynes, Tacoma, Wash., Isadore Chertoff, Bayonne, New Jersey, Kenneth P. Carlson, North Platte, Nebraska, Hyman Marcus, New York City, Daniel Finkel, New York, W. E. Buker, Pittsburgh, Pa.

1461. *Proposed by Norman Anning, University of Michigan.*

Show that, if we take the four numbers $\sqrt{2}$, $\sqrt{3}$, 2, $\sqrt{6}$ and from the sum of any pair, subtract the sum of the other pair, the result will be the exact value of the tangent of some integral multiple of $7\frac{1}{2}$ degrees.

Solution by A. R. Haynes, Tacoma, Washington.

There will be six differences in the combinations of four things taken two at a time. Also of these differences, three sets will be found to be the negative of the other three, therefore, we have to find

$$\tan^{-1} \pm [(\sqrt{2}+\sqrt{6}) - (\sqrt{3}+2)] \quad (1)$$

$$\tan^{-1} \pm [(\sqrt{3}+\sqrt{6}) - (\sqrt{2}+2)] \quad (2)$$

$$\tan^{-1} \pm [(2+\sqrt{6}) - (\sqrt{2}+\sqrt{3})]. \quad 3)$$

1. Tan $7\frac{1}{2}$ will first be derived.

Let

$$\tan 2A = \frac{2 \tan A}{1 - \tan^2 A} = K$$

then

$$\tan A = \frac{-1 \pm \sqrt{1+K^2}}{K}. \quad (4)$$

Taking the upper sign and letting $2A = 30$, $K = \sqrt{3}/3$ and

$$\tan 15 = 2 - \sqrt{3} = K'.$$

A second application gives

$$\tan 7\tfrac{1}{2} = [(\sqrt{2}+\sqrt{6}) - (2+\sqrt{3})].$$

Hence for (1),

$$\tan \pm 7\tfrac{1}{2} = \pm [(\sqrt{2}+\sqrt{6}) - (\sqrt{3}+2)].$$

2. The multiples, m, of $7\frac{1}{2}$ will now be examined:

m	Angle	Remark
1*	$7\frac{1}{2}$	Found—Sec. 1.
2	15	Found—Sec. 1.
3	$22\frac{1}{2}$	Well known to be $\sqrt{2}-1$.
4.	30	Well Known
5*	$37\frac{1}{2}$	To be determined
6.	45	Known
7*	$52\frac{1}{2}$	To be determined
8	60	Known

Other values may be determined from the relation $\tan x = \cot (90-x)$
For $37\frac{1}{2}$, $\tan 37\frac{1}{2} = \tan (45-7\frac{1}{2})$
Expanding and remembering $\tan 45 = 1$ and

$$\tan 7\tfrac{1}{2} = [(\sqrt{2}+\sqrt{6})-(\sqrt{3}+2)]$$

we have,

$$\tan 37\tfrac{1}{2} = \frac{1-[(\sqrt{2}+\sqrt{6})-(\sqrt{3}+2)]}{1+[(\sqrt{2}+\sqrt{6})-(\sqrt{3}+2)]} = \frac{\sqrt{3}-\sqrt{2}}{\sqrt{2}-1}. \tag{5}$$

Rationalizing,

$$\tan 37\tfrac{1}{2} = (\sqrt{3}+\sqrt{6})-(2+\sqrt{2}).$$

Hence, for (2)

$$\tan \pm 37\tfrac{1}{2} = \pm(\sqrt{3}+\sqrt{6})-(2+\sqrt{2}).$$

3. For $52\frac{1}{2}$ we have, $\tan 52\frac{1}{2} = \cot (90-52\frac{1}{2}) = \cot 37\frac{1}{2}$ and

$$\cot 37\tfrac{1}{2} = \frac{1}{\tan 37\frac{1}{2}} \text{ where } \tan 37\tfrac{1}{2} = \frac{\sqrt{3}-\sqrt{2}}{\sqrt{2}-1}.$$

Therefore,

$$\tan 52\tfrac{1}{2} = \frac{\sqrt{2}-1}{\sqrt{3}-\sqrt{2}}.$$

Rationalizing, $\tan 52\frac{1}{2} = (2+\sqrt{6})-(\sqrt{2}+\sqrt{3})$. Hence, for (3), $\tan \pm 52\frac{1}{2} = \pm[(2+\sqrt{6})-(\sqrt{2}+\sqrt{3})]$.

A solution was also offered by Hyman Marcus, New York City. Mr. Marcus carries out the work for the following integral multiples of $7\frac{1}{2}$: 1, 5, 7, 17, 19, 23 which satisfy the conditions. The manipulation of the radicals is left to the reader. The proposer points out the following interesting relation: $\text{Tan } 82.5 = \tan 11(7.5) = \sqrt{6}+\sqrt{3}+\sqrt{2}+2$.

1462. *Proposed by a teacher.*

Show that, if $\tan x+\tan y+\tan z = \tan x \tan y \tan z$, then $1-\tan y \tan z-\tan z \tan x-\tan x \tan y = \pm \sec x \sec y \sec z$.

Solution by Isadore Chertoff, Bayonne, N. J.

$$\tan (x+y+z) = \frac{\tan x+\tan y+\tan z-\tan x\cdot\tan y\cdot\tan z}{1-\tan x\cdot\tan z-\tan z\cdot\tan x-\tan x\cdot\tan y}. \tag{1}$$

Since $\tan x+\tan y+\tan z = \tan x\cdot\tan y\cdot\tan z$ the numerator of (1) is 0, and $\tan (x+y+z) = 0$ $\therefore x+y+z = n\pi$ and $\cos (x+y+z) = \cos n\pi = \pm 1$.

Expanding $\cos(x+y+z)$ and factoring right member we obtain
$\cos(x+y+z)=\cos x\cdot\cos y\cdot\cos z\,(1-\tan y\cdot\tan z-\tan z\cdot\tan x-\tan x\cdot\tan y)=\pm 1$
$\therefore 1-\tan y\cdot\tan z-\tan z\cdot\tan x-\tan x\cdot\tan y=\pm\sec x\cdot\sec y\cdot\sec z.$
Solutions were also offered by Maxwell Reade, Julius Freilich, Brooklyn, A. R. Haynes, Tacoma, Wash., Hyman Marcus, New York City, and the author.

1463. *Proposed by Max Fowler, Centralia, Ill.*

The sum of the squares of the medians of a triangle is equal to three fourths of the squares of the sides.

Solution by M. Freed, Wilmington, California.

Let m_a, m_b, and m_c denote the medians upon the sides a, b, and c of a triangle.
Then

$$m_a=\tfrac{1}{2}\sqrt{2(b^2+c^2)-a^2}$$

or

$$m_a^2=-\frac{a^2}{4}+\frac{b^2}{2}+\frac{c^2}{2}.$$

Similarly

$$m_b^2=\frac{a^2}{2}-\frac{b^2}{4}+\frac{c^2}{2}$$

$$m_c^2=\frac{a^2}{2}+\frac{b^2}{2}-\frac{c^2}{4}.$$

By adding we get $m_a^2+m_b^2+m_c^2=3/4a^2+3/4b^2+3/4c^2$
Solutions were also offered by H. R. Mutch, Glen Rock, Pa., Julius Freilich, Brooklyn, N. Y., Ortho Stimmett, Tohlequah, Oklahoma, W. E. Buker, Pittsburgh, Pa., David Blackwell, University of Illinois, John M. Lake, Fillmore, N. Y., Isadore Chertoff, Bayonne, N. J., A. R. Haynes, Tacoma, Wash., Kenneth P. Carlson, North Platte, Nebraska, Margaret Joseph, Milwaukee, Wisconsin, Hyman Marcus, New York City, and Robert R. Creighton, Audubon, N. J.

1464. *Proposed by Cecil B. Read, Wichita, Kan.*

Given: A circle with any two fixed points A and B within the circle and a given angle $\angle x$.
To construct: An angle equal to given angle, x, with its vertex upon the circle and it sides passing through the given points.

Solution offered by John B. Palmer, Philadelphia, Pa.

On line AB construct two circular segments which shall contain the given angle as an inscribed angle. The arcs of these segments then form the loci of the vertices of angles equal to the given angle whose sides pass through the given points.
Note: Obviously the intersection of these loci with the given circle determine the vertices of the angles satisfying the conditions of the problem.
These intersections will vary in number from zero to four depending on whether the distance between A and B is short or long in comparison with the radius and if the size of the angle is near 90° or not. If both the circular segments intersect the given circle the four points will result. If one is

tangent to the given circle and the other intersects three points will result. If one intersects and the other is within the circle or if both are tangent two points will result. If only one is tangent and the other is within the circle only one will result. If both are within the circle no points will result.

Solutions were also offered by H. R. Mutch, Glen Rock, Pa., A. R. Haynes, Tacoma, Wash., and Isadore Chertoff, Bayonne, N. J.

1465. *Proposed by Amory R. Haynes, Tacoma, Wash.*

If $a+b+c=0$, show that

$$\frac{a^5+b^5+c^5}{a^2+b^2+c^2}=\frac{5(a^7+b^7+c^7)}{7(a^4+b^4+c)}.$$

First Solution by the proposer.

a, b, c are the roots of $x^3+px+q=0$ where $a+b+c=0$ and

$$bc+ca+ab=p. \tag{1}$$

Also $a^2+b^2+c^2=(a+b+c)^2-2(bc+ca+ab),=-2p$, since $a+b+c=0$. Again, by substitution of roots for x in $x^3+px+q=0$,

$$\left.\begin{aligned} a^3+pa+q&=0\\ b^3+pb+q&=0\\ c^3+pc+q&=0 \end{aligned}\right\} \tag{4}$$

adding,

$$a^3+b^3+c^3+p(a+b+c)+3q=0,$$

whence

$$a^3+b^3+c^3=-3q. \tag{5}$$

Multiplying (4) in order by a^{n-3}, b^{n-3}, c^{n-3} and adding,

$$a^n+b^n+c^n+p(a^{n-2}+b^{n-2}+c^{n-2})+q(a^{n-3}+b^{n-3}+c^{n-3})=0.$$

Letting $n=4$,

$$a^4+b^4+c^4+p(a^2+b^2+c^2)+q(a+b+c)=0,$$

Substituting from (3) and remembering $(a+b+c)=0$,

$$a^4+b^4+c^4=2p^2 \tag{6}$$

$$a^5+b^5+c^5=5pq. \tag{7}$$

Similarly

$$a^6+b^6+c^6=3q^2-2p^3 \tag{8}$$

$$a^7+b^7+c^7=-7p^2q. \tag{9}$$

Then

$$\frac{a^5+b^5+c^5}{a^2+b^2+c^2}=\frac{5pq}{-2p}=-\frac{5}{2}q \tag{10}$$

and

$$\frac{5}{7}\,\frac{(a^7+b^7+c^7)}{(a^4+b^4+c^4)}=\frac{5}{7}\,\frac{(-7p^2q)}{(2p^2)}=-\frac{5}{2}q. \tag{11}$$

Hence by (10) and (11),

$$\frac{a^5+b^5+c^5}{a^2+b^2+c^2}=\frac{5}{7}\,\frac{(a^7+b^7+c^7)}{(a^4+b^4+c^4)}.$$

Second Solution by Isadore Chertoff

Let

$$\frac{a}{b}=k \quad \therefore \quad \frac{a+b}{b}=\frac{-c}{b}=k+1$$

then

$$\frac{a^5+b^5}{b^5}=k^5+1 \quad \text{and} \quad \frac{c^5}{b^5}=-(k+1)^5$$

$$\therefore \quad \frac{a^5+b^5+c^5}{b^5}=k^5+1-(k+1)^5. \tag{1}$$

In same manner

$$\frac{a^2+b^2}{b^2}=k^2+1 \quad \text{and} \quad \frac{c^2}{b^2}=(k+1)^2$$

$$\therefore \quad \frac{a^2+b^2+c^2}{b^2}=k^2+1+(k+1)^2. \tag{2}$$

Dividing (1) by (2)

$$\frac{a^5+b^5+c^5}{b^3(a^2+b^2+c^2)}=\left[\frac{k^5+1-(k+1)^5}{k^2+1+(k+1)^2}\right]=\frac{-5k(k^3+2k^2+2k+1)}{2(k^2+k+1)}=\frac{-5k(k+1)}{2} \tag{3}$$

Similarly

$$\frac{a^7+b^7+c^7}{b^3(a^4+b^4+c^4)}=\left[\frac{k^7+1-(k+1)^7}{k^4+1+(k+1)^4}\right]=\frac{-7k(k^5+3k^4+5k^3+5k^2+3k+1)}{2(k^4+2k^3+3k^2+2k+1)}$$
$$=\frac{-7k(k+1)}{2}. \tag{4}$$

Dividing (3) by (4) and simplifying

$$\frac{a^5+b^5+c^5}{a^2+b^2+c^2}=\frac{5}{7}\,\frac{(a^7+b^7+c^7)}{(a^4+b^4+c^4)}.$$

Solutions were also offered by Maxwell Reade, H. R. Mutch, Glen Rock, Pa., Hyman Marcus, New York City, W. E. Buker, Pittsburgh, Pa., Kate Ecklea, Columbus, Miss.

Note: Mr. Mutch gives Smith's "*A Treatise in Algebra*" pages 124, 125, as a reference to problems of this sort.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1463. *Max Fowler, Centralia, Illinois. George H. Miller, St. Andrews (N.B. Canada) High School.*

PROBLEMS FOR SOLUTION

1478. *Proposed by Cecil B. Read, Wichita, Kansas.*

For high school students: which is the greater ratio, $(x^2+y^2):x+y$ or $(x^2-y^2):(x-y)$ if x and y are positive numbers.

1479. Find two simple fractions whose denominators are 5 and 9 and whose sum is 2 23/45.

1480. *Proposed by J. C. Hall, Butte, Mont.*

Solve for x, y and z, the equations:

$$x^2+y^2+xy=19.$$
$$x^2+z^2+xz=13.$$
$$y^2+z^2+yz=\ 7.$$

1481. If $a=\sin 5°$, $b=\sin 49°$, $c=\sin 87°$, show that $\sin 73° = \dfrac{a^2-b^2+ac}{4a(a^2-b^2+ac)-(a-b+c)}$.

1482. *Proposed by W. W. Taylor, Port Arthur, Texas.*

Construct a triangle, given the difference of the segments of the base into which it is divided by the foot of the altitude, the difference of the base angles, and the ratio of the other two sides.

1483. *Proposed by Cecil B. Read, Wichita, Kansas.*

Find without use of calculus the maximum value of $a \cos x + b \sin x$.

SCIENCE QUESTIONS

January, 1937

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio

Please send copies of Tests and Examinations to Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

Send your most interesting question in Biology, Chemistry, General Science, or Physics. Join the GQRA (Guild Question Raisers & Answers). Have your class answer or propose a problem or question.

WHAT IS NEW FOR 1937?

777. This is not a mere question. What really *is* going to be done in Science Teaching in 1937 that is *new* or *different?*

Please send in your answer (or comments).

MAGNETISM SHARPENS RAZOR BLADES

778. *Proposed by Glenn F. Hewitt, (GQRA No. 151) Chicago, Ill.*

Suggested by a newspaper clipping: "Gilbert Coleridge, London, uses a compass to make his razor blades last longer. He lays the used blade on the window sill so it points due north. Terrestrial magnetism, he claims, keeps it sharp."

How much effect would Terrestrial magnetism have in keeping one's razor blades sharp? Would the effect be more noticeable in London than in Chicago?

SPEED AND SAFETY

779. It is stated in charts and newspapers, as though matters of common knowledge, that—

(*a*) "It requires 126 feet to stop a car traveling at 40 miles per hour."

(*b*) "The distance required to stop a car at 60 miles per hour is 263 feet, more than double the distance required to stop an auto going 40 miles an hour."

Please send in demonstrations of these statements.

Make up some problems based on the above or similar statements and send them in.

Who is "Interested," Newark, N. J.?

Please send name and address to the Editor of Science Questions.

ANSWERS TO THE MYSTERY PROBLEM NO. 767

By Lawrence Kerr, Corsica, Pa. (Elected to the GQRA No. 156).

Dear Mr. Jones,

In the October issue of SCHOOL SCIENCE AND MATHEMATICS, page 801, there is one of your "Think Questions."

May I offer my suggestion as to the odd or peculiar part of the story.

This story is written in the third person.

The ladies were playing cards.

The dream victim came to take his wife home with him.

Now this man went out on the porch and fell asleep while waiting for his wife. It was during this sleep that the dream and death occurred.

If the story had been told in the first person, namely, the dreamer, then it would have been quite possible; but no, it is in the third which makes it impossible for the ladies or anyone to know what was passing through the mind of the dreamer because he died instantly at the tap of the glove on his neck.

Now Mr. Jones recognizing the fact that the man spoke to nobody and was spoken to by none of the ladies after his sleep, does it not seem peculiar or odd that anyone would be able to say the man was even dreaming, much less, to be able to tell his dream.

Am I right or wrong, Mr. Jones. Please let me know.

Answer: You are correct.

By Sister Mary Vincenza, RSM, and Chemistry Class, Mercy High School, Chicago, Ill. (Elected to the GQRA, No. 155.)

Dear Mr. Jones,

In regard to Mr. Glenn F. Hewitt's question in Oct. 1936 Journal, I would say that my Chemistry Class think it very odd that the author would have any means of knowing what the man was dreaming if he died of shock without waking to tell of his bad dream.

FROZEN WATER PIPES

755. *Proposed by Olive May Draper (GQRA, No. 137), Taylor University, Upland, Ind.*

I have been told several times this winter that the warm weather drives the frost down into the ground, and that is why the water lines were frozen. Is that the reason?

The specific example was this: there was a long spell of very cold

weather followed by one mild day, when the surface of the ground became muddy in spots, and some snow melted off. It turned cold towards morning, and that morning three water lines in this immediate neighborhood were frozen.

I would appreciate comments from your members.

Comments by James W. Wilbur (GQRA No. 150).
Calumet High School, Chicago, Ill.

Dear Sir:

Something has stimulated me to want to make remarks concerning several of your questions this month. The one about frozen pipes is so characteristic of the popular nonsense offered for explanations in so many cases. If the following suits, you may print it.

Heat is always found to flow from a higher toward a lower temperature through solids by a process called conduction. The rate of flow depends upon the kind of material as well as rate of change of temperature from point to point along the conducting material. In this case the long period of cold had caused much heat to flow out of the ground bringing it to a temperature below the freezing temperature of water for a considerable distance into the ground, presumably down as far as the water pipes. Conduction through the ground is so slow that a day or two of warm or cold weather would have no effect on what took place at the depth of the pipes. Heat would keep flowing into the sub-freezing temperature that had been established about the pipes and when the water in the pipes became as cold as freezing further loss of heat would result in freezing. A common way to prevent freezing of water pipes is to leave the faucet open so that the water flows out before it gets cold enough to freeze. Perhaps warm weather causes people to lose their caution and stop doing this too soon.

Comments by Norman S. Greiner, (GQRA, No. 91) Somerville, N. H.

Upon reading your Science Questions for May, 1936, I notice that several questions are unanswered. I have answers for several of these which I am submitting for your consideration.

1. Question 734—Proposed by Joseph A. Nyberg—"Does hot water freeze faster than cold water?

I think this is answered by a reference from Weld and Palmer's *A Textbook of Modern Physics*, page 244, Chapter 14. Effects and Measurement of Heat" I quote "Any plumber will testify that hot water pipes more often suffer from freezing than cold water pipes. Recent experiments have shown that this is probably due to the fact that the water which has not been boiled contains air and expels it on freezing, thus forming a cushion of bubbles that takes up the expansion." As a result the change from the liquid to solid state is delayed in the cold water—my own opinion.

TESTS IN ELECTRICITY

Submitted by Wm. A. Porter (GQRA No. 148), Chisholm, Minn.

EXERCISE

TRUE FALSE EXAMINATION

Induced Currents

1. A current that flows in one direction for a short time then reverses and flows in the opposite direction for an equal time is called an alternating current.
2. The transformer is a device for changing alternating current to direct.
3. The rotor in a dynamo supplies the magnetic field.

4. Lenz's law is only an adaptation electrically of the law of conservation of energy.
5. The properties of induced currents were studied extensively by Faraday.
6. The voltage developed in a wire cutting a field is inversely proport to the velocity of the wire.
7. By moving a coil of wire across the field of a magnet a direct current is produced.
8. An alternating current cannot be used in charging a battery.
9. The slip ring commutator is used in the alternator.
10. The E.M F. reaches a minimum when the armature coils are cutting the maximum number of lines of force.
11. The strength of an induced E.M.F. depends on the number of lines of force cut.
12. A transformer requires A.C. for its operation.
13. No current flows through the primary of a well designed transformer when no current is taken from the secondary.
14. A dynamo is a device that is used to transform mechanical energy into electrical energy.
15. The rule used for finding the direction a current carrying conductor moves when in a magnetic field is called the motor rule.
16. The law I equals E/R as stated must be changed when A.C. is the type of current used.
17. The induced current is always in such a direction as to oppose the inducing device.
18. An alternating current is found in the armature of all dynamos.
19. When a conductor is moved in a direction parallel to a powerful magnetic field no current is produced.
20. An induced E.M.F. is identical in meaning to an induced current.
21. Lamps and heating appliances require alternating current for their proper operation.
22. The motor is a device for changing mechanical energy into electrical energy.
23. In the telephone circuit the induction coil steps up the current.
24. A motor generator may be used to convert an alternating current into a direct current.
25. The torque of a D.C. motor increases as the speed decreases.
26. The current travelling through the armature of an electric motor becomes less as the motor picks up speed.
27. Rectifiers of the thermionic type may be used to change an A.C. to D.C.
28. Dynamo armatures may be either ring or drum wound.
29. The shunt wound dynamo produces the most even voltage under changing load.
30. A direct current may be changed to an alternating current by an induction coil.
31. A.C. may be used to electroplate.
32. One of the big advantages of induction motors is their lack of complicated parts.
33. Most large motors require starting boxes.
34. The voice currents in a telephone are produced by the receiver.
35. Armature cores are laminated to prevent "eddy currents."
36. A device that takes in A.C. at LLO volts and changes it to A.C. at 550 volts is called a step down transformer.
37. The ring wound armature is used in very large dynamos.
38. All self exciting dynamos produce D.C.

39. The current in a rectifier of the tungar type ACTUALLY flows from the filament to the plate.
40. The nodon valve is a rectifying device.
41. The line loss in a transmission line carrying 1,000 amperes is twice that of a line carrying 500 amperes.
42. In a transformer as the voltage is increased the amperage is decreased in proportion.

PLEASE SEND IN QUESTIONS AND TESTS
JOIN THE GQRA

BOOKS AND PAMPHLETS RECEIVED

An Elementary Survey of Modern Physics, by Gordon Ferrie Hull, Professor of Physics, Dartmouth College. Cloth. Pages xxiv+457. 13.5×21.5 cm. 1936. The Macmillan Company, 60 Fifth Avenue, New York, N.Y. Price $4.50.

Directed Activities, III a Workbook to Guide Pupils in Their Study of Man's Control of his Environment, by Samuel Ralph Powers, Professor of Natural Sciences, Teachers College, Columbia University; Elsie Flint Neuner, Supervisor of Elementary Science, New Rochelle, New York; and Herbert Bascom Bruner, Professor of Education, Teachers College, Columbia University. Paper. Pages iii+151. 19×27.5 cm. 1936. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price 52 cents.

Number Stories Work Book, Number Two, by W. C. Findley, J. W. Studebaker and F. B. Knight. Paper. 96 pages. 20×28 cm. 1936. Scott, Foresman and Company, Chicago, Ill. Price 32 cents.

The High-School Science Library for 1935–1936, by Hanor A. Webb, Editor of *Current Science*, George Peabody College for Teachers, Nashville, Tennessee. Reprinted from the *Peabody Journal of Education*, Volume 14, No. 2, September, 1936. 17 pages. 17×24.5 cm. Price 15 cents.

Suggested Theory of The Future Mid-West, by A. A. Alles, 1413 Federal Street, Pittsburgh, Pennsylvania. Paper. 26 pages. 12.5×18 cm. 1936. Price 40 cents.

Answers to Problems in A Textbook of Physics, by Charles A. Culver, Professor Physics in Carleton College, Paper. 5 pages. 14.5×21.5 cm. 1936. The Macmillan Company, 60 Fifth Avenue, New York. N. Y.

Portraits of Eminent Mathematicians with Brief Biographical Sketches, by David Eugene Smith, Professor Emeritus of Mathematics, Columbia University. Portfolio Number One. 12 portraits: Archimedes, Copernicus, Viete, Galileo, Napier, Descartes, Newton, Leibnitz, Lagrange, Gauss, Lobachevsky, Sylvester. 26×36 cm. 1936. Scripta Mathematica, Yeshiva College, Amsterdam and 186th Street, New York, N. Y. Price $3.00.

Science Teachers Section, Private Schools Association of the Central States, First Annual Bulletin on New Books and Industrial Teaching Aids. Mimeographed Bulletin. 30 pages. 21.5×28 cm. 1936. Hal. Baurd, Secretary, Francis W. Parker School, 330 Webster Avenue, Chicago, Ill. Price 75 cents.

Cambridge Tracts in Mathematics and Mathematical Physics, No. 34, The Rational Quartic Curve in Space of Three and Four Dimensions, by H. G. Telling. Paper. Pages vi+78. 14×22 cm. 1936. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.75.

Institute of International Education, Seventeenth Series, Bulletin No. 4. The American University Union in Europe. Paper. 46 pages. 14.5×23 cm. 1936. Institute of International Education, 2 West 45th Street, New York, N. Y.

Institute of International Education, Seventeenth Series. Bulletin No. 5. Seventeenth Annual Report of the Director. Paper. 48 pages. 14.5×23 cm. 1936. Institute of International Education, 2 West 45th Street, New York, N. Y.

Multifoliate Monographs. Monograph One, Bifoliate Numbers, by Robert Ashby Philip. Paper. 56 pages. 21×28 cm. 1935. The Monographic Press, 106 Washington Street, Fairhaven, Mass.

Balopticons and Accessories, Catalog E-11. Paper. 26 pages. 21.5×28 cm. Bausch and Lomb, Optical Company, Rochester, N. Y.

BOOK REVIEWS

Animal Micrology, Practical Exercises in Zoological Micro-Technique, by Michael F. Guyer, Professor of Zoology in the University of Wisconsin, *with a chapter on drawing*, by Elizabeth A. (Smith) Bean, former Assistant Professor in Zoology in the University of Wisconsin. Fourth revised edition. Cloth. Pages xvi+331. 15×22 cm. 1936. The University of Chicago Press, Chicago, Illinois. Price $2.50.

The first edition of this popular handbook of histological technique appeared in 1906. Its use during thirty years, through three editions, in many laboratories has served in selecting and improving the methods now described. Following his original plan, the author writes with the beginner in mind; his aim is not to write an encyclopedia of technique nor a catalogue of all possible procedures, but a representative series of reliable standard methods. The needs of the student, the zoology teacher, and the physician are all considered.

The author feels that a description of the new dioxan method is alone sufficient justification of a new edition just six years after the last. This method (first published in Germany in 1931) makes use of a new dehydrating agent, diethyl-dioxide, miscible both with water and paraffin, which not only saves steps and time, but avoids the undue hardening of tissues resulting from the ordinary methods with absolute alcohol.

No zoology laboratory should be without a book of this type even though the instructor does not prepare his own permanent slides, since there are many valuable suggestions for the handling of living material, ranging all the way from the culturing of Protozoa to the preparation of slides of fresh blood of vertebrates.

The book is especially commendable for its clearness of expression, orderly arrangement of contents, complete index, and excellent typography.

EDWARD C. COLIN

Procedure in Taxonomy, by Edward T. Schenk and John H. McMasters. Cloth. Pages vii+72. 15×23 cm. 1936. Standford University Press, Stanford, California. Price $2.00.

This book is made up of two parts. The first, *Procedure in Taxonomy*, consists of a brief statement (24 pages) of principles and rules designed for the one who sets out to name and describe a new species. The topics treated are as follows: Systematic Categories: Types; The Description of a New Species; Specific Names; Synonymy; Storage of Type Material; and Latin Terms and Abbreviations. Problems relating to the above have in the authors' view become involved and burdensome to the extent of discouraging the student who wishes to contribute semething of lasting value in taxonomy. It is to smooth the way for such that they have written notes on taxonomic procedure. Undoubtedly they have accomplished their purpose.

The second part (30 pages) consists of a reprint of the *International Rules of Zoological Nomenclature* with *Summaries of Opinions Rendered* to the present date. To the systematist these are, of course, indispensable, just as the statutes and judicial opinions are indispensable to the lawyer.

A complete index covers both parts of the book.

EDWARD C. COLIN

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Please Mention *School Science and Mathematics* when answering Advertisements

Descriptive Geometry, by C. H. Schumann, Jr., Associative Professor and Executive Officer, Department of Drafting, Columbia University. Second Edition. Cloth. Pages xi+336. 15×23 cm. 1936. D. Van Nostrand Co., Inc. 250 Fourth Avenue, New York, N. Y. Price $2.75.

While there is still much difference of opinion among those who teach descriptive geometry as to whether instruction should be based upon the "conventional" method or the "direct projection" method, it is apparent that authors of recent texts on the subject recognize the importance of a balanced emphasis upon these two methods. In such texts, the dual purpose of descriptive geometry in the curriculum is, thereby, recognized and training is thus provided in direct practical applications as well as in purely mental discipline.

In this respect, the revised edition of Schumann's "Descriptive Geometry" presents the subject matter with these combined objectives very satisfactorily considered. Where simplicity or directness of solutions would result, or where engineering practice would require it, the direct projection method is introduced and its application to practical problems is clearly set forth.

The work has many well drawn and easily read illustrations and provides a copious supply of some 1,800 drill exercises. The descriptive text is clear and sufficiently extended with explanatory matter to provide a logical introduction to, and development of, a rather difficult subject.

H. D. ROLLER

Analytic Geometry, by John Wesley Young, Late Cheney Professor of Mathematics, Dartmouth College; Tomlinson Fort, Professor of Mathematics, Lehigh University: and Frank Millett Morgan, Director of Clark School, Formerly Assistant Professor of Mathematics, Dartmouth College. Cloth. Pages x+347. 13×20 cm. 1936. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price $2.25.

This book is based on an unfinished manuscript on Analytic Geometry written by the late John Wesley Young. Professors Fort and Morgan, at the request of the Houghton Mifflin Company, collaborated in completing the manuscript.

The book is designed to meet the requirements of a freshman course in Analytic Geometry as given in an Arts College or an Engineering School. There are sixteen chapters. The first chapter deals with review material, such as the general quadratic equation, determinants, trigonometric identities, directed line segments, and projection of line segments. Chapters II–XI inclusive deal with the usual topics of plane analytic geometry. Chapters XII–XIV deal with solid geometry, and chapters XV and XVI deal with the derivative and its applications.

There are numerous problems which seem to be well graded. In general the last third of the problems of an exercise are designed for superior students. As a work of art the book ranks very high.

J. M. KINNEY

Practical Mathematics, by N. J. Lennes, Cloth. Pages xi+400. 14×20.5 ×2 75 cm. 1936. The Macmillan Company, New York. Price $1.20.

Practical Mathematics is a textbook-that succeeds well in bridging the gap between mathematics and the social studies; it presents mathematics not as a cold mental discipline but rather as an immediate aid to a fuller understanding and a deeper enjoyment of life.

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This book is intended as a text in a course for high school freshmen, all parts of which shall be of direct practical value to the learner. The book presupposes no preparation beyond ordinary arithmetic and contains some algebra and geometry. For the teachers who have had discouraging experiences with many a high school freshmen this book should be a welcome relief and is doubtless a valuable book for orientation courses that lead to the study of high school mathematics.

JOSEPH J. URBANCEK

Business Mathematics, by Cleon C. Richtmeyer, Professor of Mathematics, Central State Teachers College, Mt. Pleasant, Michigan, and Judson W. Foust, Assistant Professor of Mathematics, Central State Teachers College, Mt. Pleasant, Michigan. Cloth. First Edition. Pages xii+250. 2×14×21 cm. 1936. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.00.

This book is designed primarily for college classes that include students who are preparing to teach commercial arithmetic in the secondary schools, students who are planning to enter the various commercial fields, or students who wish a general course in practical mathematics with businesss aspects. Presupposing only the usual mathematics of the elementary and secondary schools, this book seeks to acquaint the student with a wide variety of topics. Each topic is developed at length, followed by illustrations worked out in detail, and accompanied by step-by-step explanations. Throughout, natural and fundamental principles are emphasized and unusual and "trick" short-cuts are avoided. Algebra and symbolism are kept to a minimum, and new techniques are acquired in connection with topics in which they are used. Seventy-nine different topics are treated, ranging from simple arithmetical processes, through mathematics fundamental to finance, to statistics for the business man. All necessary tables are provided, including a five-place table of logarithms, interest and annuity tables, and a table of powers, roots, and reciprocals.

JOSEPH J. URBANCEK

Mathematics For Technical and Vocational Schools, by Samuel Slade, B.S., C.E., Assistant to the Director of Vocational Activities, New York City Board of Education, and Louis Margolis, A.B., C.E., Brooklyn Industrial High School, Jamaica Evening Trade School, City of New York. Pages xiii+517. First Edition 1922, Second Edition 1936. John Wiley and Sons, Inc. New York. Chapman and Hall, Limited London.

The authors have produced a textbook on Mathematics as applied to technical and trade work. The aim is to teach the pupil to readily solve the problems that occur in his work. Therefore all theoretical discussions, derivations of formulas etc., have been practically eliminated. This text is based upon revised material used previously in classrooms in the form of blue prints and mimeographed sheets.

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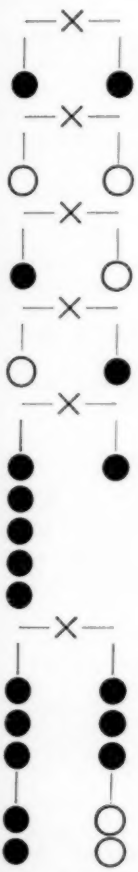

A unit pair of lead weights is called a positive unitary pair:

$$(+1\ \&\ +1) = +(1\ \&\ 1)$$

A unit pair of cork weights is called a negative unitary pair:

$$(-1\ \&\ -1) = -(1\ \&\ 1)$$

A unit pair of lead and cork weights is called a positive hemitropic pair:

$$(+1\ \&\ -1) = +(+1\ \&\ -1)$$

A unit pair of cork and lead weights is called a negative hemitropic pair:

$$(-1\ \&\ +1) = -(+1\ \&\ -1)$$

Any combination of lead and cork weights may be resolved into the sum of unitary and hemitropic pairs in one and only one way:

$$(5\ \&\ 1) = (3\ \&\ 3) + (+2\ \&\ -2)$$

The unitary component measures the force of translation at the fulcrum of the balance. Positive unitary pairs correspond to downward translation. Negative unitary pairs correspond to upward translation.

The hemitropic component measures the force of rotation at the fulcrum of the balance. Positive hemitropic pairs correspond to counter-clockwise torque. Negative hemitropic pairs correspond to clockwise torque. Zero hemitropic pairs correspond to perfect balance.

The unitary and hemitropic components of the compound number symbolize the translational and rotational componets of the force. The translational-rotational force is itself a compound physical quantity and calls for a compound number for its logical symbolization.

The mathematics of further relations of unitary and hemitropic numbers is developed in a monograph BIFOLIATE NUMBERS.

BIFOLIATE NUMBERS **Price one dollar.**

THE MONOGRAPHIC PRESS

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The second edition has been generally improved and brought up to date. Many problems have been changed and new problems added.

A rapid review of essential parts of elementary arithmetic is contained in brief chapters on fractions, decimals, ratio and proportion, and percentage. There are chapters devoted to Algebra, Geometry, and Trigonometry. One chapter consists of work based on Practical Computation and deals with simple rules consisting of the application of common sense to computation. There are included a large number of illustrative examples and problems. The tables at the back of the book are sufficient to solve all problems contained in the book.

The simplicity and clearness of this text and the great variety of illustrations and problems make this book one of great value for self-instruction and for classroom use in day and evening trade schools and technical high schools.

RAYMOND S. COLES

General Chemistry, by Harry N. Holmes, Professor of Chemistry in Oberlin College. 3d edition. pp. viii+700. 3.3×15×22 cm. 200 figures. Cloth. 1936. $3.50. Macmillan.

This is a thoroughly revised edition of the author's previous edition of 1930. While still containing much descriptive chemistry the new book also contains much of the more recent advance in theoretical and physical chemistry. The Bröensted method of treatment of acids, bases and salts and the modern ideas of complete dissociation of strong electrolytes are taught.

A new chapter on Nuclear chemistry has been added and another on Radiation chemistry. The Industrial chemistry portions of the book have been brought down to date, as well as the production and value of various important metals. A practical chapter on food and nutrition brings in the newer knowledge of the importance of vitamines in the diet.

The only item noticed by the reviewer that was not quite up to date was the current price of platinum on the new gold basis (Platinum doubled in price while the ink was drying on this new edition!).

FRANK B. WADE

A Text Book of Organic Chemistry for Students of the Medical Sciences, by Hugh C. Muldoon, D.Sc. Professor of Chemistry and Dean of the School of Pharmacy, Duquesne University. Author Laboratory Manual of Organic Chemistry. Second Edition. pp. xi plus 590. 3×15×21 cm. 33 Illustrations. Cloth. 1936. $3.00. Blakiston.

This revision has kept the general purpose and method of the original book in mind while really adding much new material and improving the arrangement and presentation of the old.

Frankly intended for students who will major in medicine or in pharmacy or in nursing or some other special science with a medical slant the text affords them much material which is of immediate concern in their other work.

The classical order of presentation is employed with some preliminary chapters on the physical chemistry most needed in the study of organic chemistry. The aliphatic compounds and their derivatives precede the ring compounds as usual. Alkaloids, proteins and hormones are briefly dealt with in the later chapters of the book.

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